Metallurgical & Chemical Engineering

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The Contributions of Chemistry to the Industries of the United States

The most prominent feature of the celebration of the fiftieth convention of the American Chemical Society, held in New Orleans last month, was the elaborate symposium of papers on contributions of the chemist to the American industries before the Industrial Section. Introduced by a brilliant address by Dr. Arthur D. Little on the industrial resources and opportunities of the South and concluded by an able summary by Dr. Bernhard C. Hesse of the record of achievements of American chemistry, the symposium proper comprised nineteen papers on the decisive influence which chemistry and the chemist have had on the development of the wine industry, the copper industry, the corn products industry, the asphalt industry, the cement industry, the sugar industry, the incandescent gas mantle industry, the textile industry, the fertilizer industry, the soda industry, the leather industry, the flour industry, the brewing industry, the preserved-foods industry, the potable water industry, the celluloid and nitrocellulose industry, the glass industry, and the pulp and paper industry.

This record of chemical achievements is certainly impressive. It is the more impressive as in a way these nineteen papers scratched only the surface. For instance, of all the contributions of chemistry to metallurgy, only those relating to copper metallurgy were dealt with. Yet it is perfectly true to say that the functions of the chemist are now looming large besides those of the mechanical and mining engineer in the modern metallurgy of any and every metal, not the least in the biggest of all metallurgical industries, that of iron and steel. And the electrometallurgical achievements of the last decades would have been simply impossible without the chemist; the aluminium industry would simply not exist had it not been for the work of the chemist.

In spite of its shortcomings this symposium was very successful. It was timely. With the popular outcry in our ears that lack of "spunk" has prevented American chemists from creating a complete dyestuff industry, it was necessary to impress on the public the fundamental fact that the sphere of influence of the chemist reaches far beyond the boundaries of the chemical industries. Indeed, the influence of chemistry reaches into every industry, just as does the influence of the mechanical engineer. But while the mechanical engineer is usually called in at the beginning of an industrial development, the function of the chemist starts generally much later, when refinements, recovery of by-products and the avoidance of waste become important. His work is not less important than that of

the mechanical engineer, but it is not equally visible, it does not impress itself directly on the public.

Of course, as all industries depend upon materials and very often upon materials which are not provided by nature but must be specially made and fitted to the case, and as this is the more true the further an industry advances, all industries depend upon chemistry. This is perfectly obvious, but it does not state the whole case. Chemistry is more than a mere collection of facts on elements, compounds, and materials. It is a habit of thought, a viewpoint. When the Perkin medal was recently presented to Dr. Edward Weston, Dr. Baekeland in his address (published in our March issue) showed in a very clever way how the "chemical viewpoint" which Weston had acquired in his youth by his electrochemical work, had helped him later in his electrical engineering work. What is true of an individual evolution is more broadly true of broad industrial developments. The solution of an industrial problem depends, first of all, upon the correct formulation of the problem. And the correct formulation of the problem depends on the viewpoint—a narrow viewpoint, based on man-made classifications and conceptions is fatal. Every new and true viewpoint that can be brought to bear upon a problem is of inestimable value. For this reason alone the chemist cannot be ignored by any industry whatsoever. What he has done in the past for the development of the American industries entitles him to hold up his head with pride. This was the keynote of the New Orleans symposium.

Nor does the American chemist need to be ashamed of the development of the American chemical industries proper. While this country has no complete dyestuff industry, it has an electrochemical industry that is the child of the American soil and is not equalled anywhere in the world. As Mr. Lidbury put it in his brilliant presidential address before the American Electrochemical Society last week, "in spite of its youth, the absence of the electrochemical industry from among the industries of the country would cause such industrial disturbance that the plaint of the wearer of many colors, always imminent but not up to the present moment audible, would pass unnoticed."

Conditions in Mexico

Villa's recent proclamation of new laws governing mining in Mexico has complicated an already intolerable situation and has stirred the representatives of foreign mining companies in Chihuahua to earnest protest. Although life and liberty there have long been in jeopardy and "57 varieties" of paper money have created financial chaos, no concerted protest has been made against high-handed methods of government until the present decree threatened the confiscation of mining property. The protest has already borne fruit; our State Department announces that exemption from the terms of the decree can be secured on proper representations to the Minister of Fomento at Chihuahua.

The reformed Article 51 of the mining law provides, in brief, forfeiture of mining property for (1) non-payment of taxes; (2) voluntary suspension of work; (3) abandonment of work; (4) insufficient exploitation, and (5) failure to "maintain in activity at least one working exploitation within each five pertenencias (10 acres), or fraction thereof." The decree announces that these restrictions are necessary in order to insure mining activity so "that the exchequer should lose none of its incomes which are indispensable for the fulfillment of its obligations." The latter evidently rest heavily on the government!

Mexican ideas of justice are beyond comprehension. Having created conditions that forced prudent people to leave the country and abandon their property until such time as they could return to it in safety, the Mexican authorities now decree that such property shall be forfeited to the country unless it is made productive and that at once. Payment of taxes, often in duplicate to successive and opposing chieftains, is not sufficient to hold title in the absence of actual operation. The fact that supplies are scarce or even unprocurable; that operations could not be conducted except at a loss, and that the terms of the decree are ridiculous from an engineering standpoint—none of these things move the Mexican chief.

Villa has been a popular leader, as leaders go in Mexico. His cause has had moral support from such engineers as have been disposed to take a partisan stand in the interests of peace in Mexico. Hitherto he has been considerate and tolerant, and has won a substantial following. Recent press dispatches indicate military reverses to his arms, but such disasters will not be as potent in effecting his downfall as will the blind and foolish enforcement of his mining decree.

The Distribution of Steel

A superstition has lately arisen that a very large proportion of the steel now being produced in the United States is passing into "war material," and it may be well not only to suggest that such is not the case, but since we have brought the subject up, to point out that the distribution of steel, into various consuming industries, is very different indeed from the distribution that obtained only a few years ago.

We must define our measuring rod first. It is commonly reported that the steel industry has lately been operating at about 70 per cent of its capacity. It is probably not far wrong to assume that the actual production in 1913, the record year, represented about 85 per cent of the present productive capacity. If so, production is now at the rate of about 25,000,000 gross tons annually of steel ingots and 19,000,000 gross tons of rolled steel, weighed in the form in which the steel leaves the hot rolls and shears.

Since the early weeks of the war there have been constant rumors of very large orders being placed for steel for war purposes, but the official statistics of exports as they have appeared month by month have successively proved the incorrectness of the major portion of the reports that had been circulated. In recent weeks the reports have become more insistent, but in the light of previous experiences we are justified in discounting them very heavily. The latest official returns, made public

within the past ten days, are for February and show total exports of all iron and steel returned by weight of 144,366 gross tons, this comparing with 139,791 tons in January. While this shows an increase, the best month since the war started lies as far back as October, with 147,293 tons, so that the February statistics disclose no definitely increasing tendency in the total iron and steel exports. Making allowance for the scrap, pig iron and cast iron included in the February total there was left material representing about 125,000 tons of rolled steel, representing 7.9 per cent of the current production. If the exports had since increased by one-half, which is quite improbable, they would represent only 12 per cent of the current production. In any event, a very considerable part of the material exported is not for war purposes. Nor can any very large tonnage of war steel be concealed in other listings than as tonnage exports, as unclassified manufactures of steel show decreases instead of increases since the war started. Even with a large percentage increase in the exports of lathes and other machine tools, lately required for the manufacture of arms and projectiles, the exports of this class of machinery have increased only by something like $1,000,000 per month in value, so that the weight of iron and steel involved can amount to but a very few thousands of tons a month. Exports of motor trucks appear large simply because there was very little such business before the war, an average of less than 100 trucks per month, while the exports in February were 1002 trucks and, in the eight months ending February, 4974 trucks. There was, however, a large decrease in exports of pleasure cars. The exports at present evidently represent less than 5000 tons of iron and steel per month, and not much more than before the war.

There is reason to conclude, therefore, that the total exports of the United States do not involve more than 15 per cent, possibly no more than 10 per cent, of the steel now being produced.

The steel that remains at home is being distributed quite differently than a few years ago. In 1906 the production of steel rails for home consumption was 3,650,000 tons, or 21 per cent of the total finished steel output. At the present time rails for domestic consumption represent considerably less than 10 per cent of the current steel output. In 1906 structural shapes represented more than 12 per cent of the total steel output. The reports of fabricated steel contracts let show an average of 51,000 net tons per month in December, January and February, and 110,000 net tons in March. A considerable proportion of this tonnage is plates, while there is very little consumption of structural shapes in car building and miscellaneous work, and it may be estimated that about one-half as large a percentage of the current steel output is passing into structural shapes than was the case in 1906. In 1906 nearly 7000 locomotives and 240,000 freight cars were built, involving about 4,000,000 gross tons of steel, or 23 per cent of the steel output. To-day it is certain that less than 5 per cent of the current steel output is passing into cars and locomotives for domestic use.

In practically all the other lines of steel consumption the percentages have greatly increased since 1906. The motor-car industry has risen from practically nothing, and in the past few months, the height of the manufacturing season, has probably been taking from 3 to 5 per cent of the current steel output, apart from its consumption of castings and forgings. The tin-plate industry is consuming more than 6 per cent of the finished steel output at present, against 3.3 per cent in 1906. The sheet industry accounted for 6.2 per cent of the steel output in 1906, and now involves a slightly larger proportion. In wire, wrought pipe and merchant bars the proportions have very greatly increased.

It is possible to generalize from this comparison and to observe that steel is passing much more into the articles of common everyday consumption and much less, proportionately, into large structures, such as bridges, buildings, etc., and railroad use. By no means does it follow, of course, that the altered distribution is to be permanent. Rather it may be suggested that since it has been extremely difficult in the past nine months or more to effect any new financing, the time may come when large undertakings will be resumed in numbers, with, of course, no decrease but rather an increase in the common everyday consumption of steel. If so, there will be a total demand for steel that the industry as now constituted cannot possibly supply. It is reported to be operating at 70 per cent of capacity at present and it is asserted that sufficient labor could not be found to operate it at 100 per cent. The situation is fraught with interesting possibilities for the next few months.

The Government's Alaskan Railroad

Based on the acquisition of the existing Alaska Northern Railroad as a first link, the Government has undertaken the construction of a railroad from Seward to Fairbanks, Alaska, a distance of 471 miles. A branch line of 38 miles is to be built into the Matanuska coal fields. The price to be paid for the Alaska Northern is $1,150,000, a rate per mile much less than half the estimated cost for constructing the balance of the road. The commission's estimate for building 438 miles of railroad is $26,800,000.

The official route, announced by President Wilson on April 10, is from Seward, on Resurrection Bay, along the Kenai Peninsula to Turnagain Arm of Cook Inlet, thence through the Susitna Valley, across Broad Pass and down the Nenana River to Fairbanks on the Tanana River. The work is to be under the direction of the Alaska Engineering Commission, consisting of William C. Edes, chairman; Lieutenant Frederic Mears and Thomas Riggs, Jr. It is expected that about 40 miles of railroad can be constructed this year.

The adopted route will open and exploit a territory not now served by a railroad, and will assist materially in the development of two important coal fields: the Matanuska and the Nenana. A supply of fuel from these districts will be of the greatest importance to the industrial development of Alaska. Fairbanks, the inland terminus of the road, is the center of an important gold mining industry.

Readers' Views and Comments

Government Publicity Methods

To the Editor of Metallurgical & Chemical Engineering.

Sir:—Criticism of Dr. Rittman continues to fill a considerable portion of the oil journals and shows little signs of abating after more than six weeks from the date on which his discoveries were announced to the public. Since much of this criticism is based on an incomplete knowledge of the real facts in the case and is decidedly unjust to Dr. Rittman, I feel that it is only proper that I should make known certain conditions which up to now have apparently not been given proper consideration.

Dr. Rittman and myself are rivals in the development of oil-converting processes, but I do not want any advantage in this contest to come to me because of wholly unmerited personal attacks on Rittman, or criticism of him which is not only unfair, but almost wholly misdirected. In the May and June (1914) numbers of the "Journal of Industrial and Engineering Chemistry" there will be found a most scholarly and comprehensive article by M. C. Whitaker and W. F. Rittman, in which the basis of Dr. Rittman's work in oil cracking is discussed in a thoroughly scientific spirit. This article should be sufficient to establish the scientific standing of Dr. Rittman, and forces anyone who gives it careful attention to admire the patient work, and the brilliant results which were obtained. That Whitaker and Rittman have done most important and valuable work in the cracking of oils will not be doubted by anyone who takes the time to read the results obtained in these important papers.

That there have been some very unfortunate and probably highly improper publicity methods used in bringing the Rittman work before the public is undoubted, and my purpose in this statement is to place the blame where it belongs. Up to now it has been laid on both Rittman and on the newspapers, but I believe I can show that in neither case is the criticism justified.

Although Congress has repeatedly insisted that no part of the funds allotted to the government departments are to be used in press agent work, it is a matter of common knowledge that several of the government departments systematically violate these provisions. The Bureau of Mines, in particular, maintains a very active publicity department, the work of which can be well seen in the recent Rittman announcements, including the numerous personal interest stories of Rittman's muscular development, his football prowess, his helpful wife, etc., etc., ad nauseam. No person who knows anything of the scientific work of Rittman can believe for a moment that he has been a willing party to publicity efforts of such a nature.

About a year ago the newspapers of this country were filled with radium press notices. A bill was before Congress carrying an appropriation of $450,000 for radium research by the Bureau of Mines, and apparently the bureau press agents worked overtime in their efforts to convince the people of this country that radium had almost miracle-working properties. Day after day the newspapers carried press notices of a misleading, if not of a wholly false character, and no efforts seem to have been spared in this compaign of publicity. In the Associated Sunday Magazines, which form the supplement of many Sunday newspapers, on Feb. 22, 1914, there was published an article by Franklin K. Lane, and using his official title as Secretary of the Interior. The opening sentence of this article is as follows:

"When we reflect that the production of every additional half-gram of radium means the saving of a human life a day from the ravages of cancer, no question can remain of our obligation to conserve and make available for use all the radium resources of this country."

At the time this article was written it is not at all certain that a single human life had been saved by radium. As a matter of fact, eminent medical authorities insisted at that time, and still insist, that no case of deep-seated cancer has ever been cured by radium, and that its exploitation as a curative agent for cancer has been due largely, if not wholly, to the efforts of parties who expected to financially profit by it.

Personally I believe that the numerous misstatements which went through all the American newspapers a year ago were part of a systematic and organized campaign for the purpose of insuring the passage of the Bureau of Mines appropriation bill of $450,000 for radium research. There are strong reasons for believing that the officials of the Bureau of Mines knew at the time that radium had no such curative powers as were being claimed for it.

The many points of similarity between the radium publicity methods and the methods recently used to introduce the Rittman discoveries to the public, will probably be noted by anyone who cares to look into the matter. As a matter of fact I have personally seen some of the press notice sheets which were handed out to the newspapers of this country in regard to the Rittman publicity. The newspapers published these sheets in practically the identical form in which they came to them.

I do not feel that the present is a proper time to enter into any detailed explanation as to just what motives are behind the work of the Bureau of Mines in exploiting the present cracking process. I will only state my belief that beneath it all there will be found certain conditions which go back somewhat over five years and which are not in any way creditable to certain officials of the Bureau of Mines, who are concerned in the matter. I believe it will be later shown that many of the details of my experiments in bringing about equilibrium conditions in hydrocarbons, with the production of large yields of gasoline, have been known to certain officials of the Bureau of Mines for a number of years past, and that Dr. Rittman was only employed by the bureau after the publication of his brilliant work at Columbia University had proved him to be a man particularly able to serve the interests that certain officials of the Bureau of Mines had in view.

There are, however, some points in regard to this recent work of the Bureau of Mines which are probably deserving of more or less immediate attention. It is known that in the development of the Rittman process, as in the development of the radium plans of a year ago, the bureau is working in coöperation with certain private interests and under agreements which are kept carefully secret.

We know to-day that a private company, the Aetna Explosive Company, has agreed to expend $200,000 in the development of the benzol and toluol end of the Rittman process, and that at present development work on a very large scale is going on in Pittsburgh. We also know that until this work is completed no further information is to be given out in regard to the process.

It is most interesting to note that it is an explosives

concern which has advanced the money to develop this process. It is also significant that the Rittman process is stated to be capable of producing a very good yield of toluene, a material which is very much in demand at the present moment, because of the war abroad, nitrotoluene being the principal explosive used in shell charges. Since the war commenced my laboratory has been receiving repeated requests for toluene and nitrotoluene, and I personally know that inquiries for toluene and nitrotoluene in very large amounts have been made in this country in the last few months.

At this psychological moment, when any process for making toluene economically can be made to yield profits of several million dollars within the course of a comparatively few weeks, an explosives concern friendly to the Bureau of Mines makes an agreement with the bureau by which it spends $200,000 in developing the Rittman process for the production of toluene from petroleum. During the life of this secret agreement it is understood that the Aetna Company is to have the exclusive use of the Rittman inventions and of all the products which can be obtained by their operation.

It is quite evident that to carry out the successful development of any scheme for using a government process and government chemists at the present time in the production of toluol, it is most desirable that the government officials should have no knowledge as to the use to which the toluol is to be put, or its final destination. With the painstaking thoroughness which characterizes much of the work of the Bureau of Mines apparently even this detail has been carefully attended to, and it is with great relief that we read in a letter written by Van H. Manning, of the Bureau of Mines, to the *Oil, Paint and Drug Reporter* under date of March 22, 1915, as follows:

"The products derived are, of course, to be the property of the Aetna Company, and this Bureau is not aware what arrangements have been made by such company for the use or disposition of the products."

I think it is very fortunate indeed that Mr. Manning has thus been kept in entire ignorance of the purposes for which the Aetna Company desires the toluene. He is probably firmly of the belief that this toluene is to be used in making whitewash, or soap, or alarm clocks. Anything, in fact, except explosives. How very fortunate it is that in all the negotiations which have been carried out between the Aetna Company and the Bureau of Mines, neither Mr. Manning nor any of his associates should have evinced any interest as to the reasons which actuate the Aetna Company to expend this large amount of money in experimental work in return for the exclusive right to use the process during the time that the present high prices for toluol exist. Later, when all the war orders have been filled, and toluene sinks to its normal level, below the price at which toluene can be economically produced by the Rittman process in competition with coal tar distillates, then, no doubt, the Rittman process will be thrown open to the general use of the American people. But for anyone to believe that it will thus be thrown open to the use of the general public untill all the "cream" has been cautiously removed, or until the process is found to be economically inoperative, for anyone to believe that, either betrays entirely unjustified credulity, or a faith in human nature which is not in line with the past actions of the very clever politicians of the Bureau of Mines.

I do not want these statements of mine to be in any way construed as a wholesale condemnation of the working of the government departments. Some of the government departments follow as high a standard of ethics as exist anywhere. I believe the patent office, in particular, before which the Rittman process must have its final review, is wholly incorruptible. Neither do I believe that Dr. Rittman is in any way responsible for, or a knowing party to, anything improper in the plans of the Bureau of Mines. Men of the highest scientific standing and ability have apparently in the past been used as tools by the Bureau of Mines in affairs which these men would have been the first to denounce had they known their true inwardness.

I believe the time has come to turn the searchlight of publicity upon the government officials and the government departments who are concerned in such matters as I have here referred to.

Pittsburgh, Pa.   WALTER O. SNELLING.

The Western Metallurgical Field
Concentration of Carnotite Ores

The concentration of low-grade carnotite ores, which has been talked about and experimented on for so long, is now an accomplished fact, being in operation in two plants in Southwestern Colorado. The Standard Chemical Co. and the National Radium Institute have perfected methods of concentration and each has a plant that is in continuous and successful operation, that of the latter under the technical direction of the Bureau of Mines.

The necessity of concentrating the low-grade carnotite ores of Colorado has long been recognized on account of the isolation of the region in which they are found, the economic necessity of treating them at some point distance from the place of their occurrence and the high cost of transportation. In the first careful investigation made on these ores and their treatment by Dr. Herman Fleck and Prof. W. G. Haldane of the Colorado School of Mines the desirability of concentration was recognized and the principles of a process were disclosed. In their report, which was embodied in that of the Commissioner of Mines for Colorado, 1905-6, they state:

"Perhaps no method of ore dressing could be succesfully applied. The extremely fine state of division of the mineral precludes this. Magnetic methods have been experimented with, but to no effect. A microscopic observation made on the ore showed, in a sample of ore from hydraulic, carrying about 4.5 per cent. uranium oxide, that the somewhat worn but yet distinct quartz crystals composing the grains were cemented by carbonate of lime, and that the carnotite adheres to the face of the crystals after rubbing the grains free from most of the carnotite dust. This suggested a method of preliminary sliming and subsequent attrition, whereby the values in the form of slimes might be easily filter pressed or settled. Machinery for the purpose of subjecting the sand grains to attrition could readily be devised."

Subsequently, other engineers experimented along this line, and the present processes in operation are based on these principles. In the Bureau of Mines *Bulletin* 70, Messrs. Moore and Kithil discuss both wet and dry methods of concentration, and give experimental results. The definite establishment of concentrating mills in the carnotite-producing region of Colorado is an event of economic importance in the uranium, vanadium and radium industries.

Alaska Gastineau Mill

When the first unit of the new mill of the Alaska Gold Mines Co. was put in operation on February 18, 1915, the promoters of a tremendous enterprise in gold mining and milling began to see the fruition of several years of labor. That the operation of the first unit started so favorably and demonstrated a capacity beyond the calculations of the designers, is a tribute to the

conservative care with which the work has been done. As first planned, the mill was to have a total capacity of 6000 tons in 24 hours, each of the four units having a capacity of 1500 tons. Mr. Jackling has stated that it now appears that the capacity will be 2500 tons per unit, or a total of 10,000 tons per day, and that the recovery is fully up to his expectations and will check with the experimental results. The other sections of the mill will be in operation at intervals of from 40 to 60 days, and in the meantime the mine will be sufficiently opened to provide the tonnage. The ore thus far treated, coming from six widely separated points in the mine, is reported to average nearly $2 per ton.

Interest in this mill centers in the radical departure from the customary methods of milling gold ores. In general, the method adopted follows the process which is in use in concentrating low-grade prophyry copper ores in Utah and Arizona. The ore passes over grizzlies, and the oversize is broken in jaw crushers. The grizzly undersize and the product of the jaw crushers is further crushed to 2-in. size in gyratories. This is followed by roll crushing in Garfield rolls of 72 in. and 54 in., with intermediate screening. Impact screens of 10-mesh finish the dry-crushing and screening process.

Concentration begins on Garfield roughing tables and is continued on Wilfley tables. The discard is classified, the coarse portion being ground in tube-mills and the concentrating process repeated. Concentrates of different grade are the products, and these are shipped to reduction works. Some high-class concentrate is reduced to base bullion at the mill.

Chloridizing at Park City, Utah

Resumption of operations at the Park City Mills is scheduled for May 1. This plant started operations last Fall, but a short run was unsatisfactory to the operators, and it was decided to make a change in the roasting furnace in which the chloridizing operation is performed. In view of the success of the Holt-Dern roaster at the mill of the Mines Operating Co., at Park City, it was decided to install a furnace of that type. This machine has been completed and is practically installed. The ore to be treated will come from the American Flag mine. Its principal value is in silver, with some gold, lead and copper, being a typical "complex" ore. The mixture for the roast contains ore, salt and coal, and the product is subjected to leaching with a salt solution. The metals are recovered by precipitation. Details of the process as carried out at the mill of the Mines Operating Co. have been given in this journal, July, 1914, page 431. An article on a similar process at Silver City, Utah, appeared in our issue for December, 1914, page 757.

Zinc Smelting at Pittsburg, Kansas

Information from Joplin is to the effect that the Pittsburg Zinc Co. has resumed operations at its smelter, which has been idle for several years. The plant has 1600 retorts, and coal is used for fuel. J. G. Starr is in charge of operations, and associated with him are members of the Lanyon family who have long been connected with the zinc industry.

Federal Investigation of Smelters

Too late for report in our last issue we learned that Federal authorities are investigating the possibility of an unlawful combination of smelters handling Missouri lead ores. It is alleged that a combination exists to fix prices and control the market for lead ores. The Department of Commerce made a perliminary probe and was followed later by the Department of Justice. The State Attorney General also has indicated his willingness to join in the search. No announcement has been made as to the results of the investigation.

Company Reports

Nevada-Douglas Consolidated Copper Co. has been reorganized, the new company including the former Nevada-Douglas Copper Co. and Moore Mining Co. The company is erecting a mill for the treatment of copper ore by the Rankin nitric acid leaching process. The plant is not complete, work being suspended about the time the European war broke out. An assessment has been levied to provide funds to complete the plant and put it in operation.

The American Smelting & Refining Company's sixteenth annual report, covering the calendar year 1914, shows total earnings of $10,811,915; depreciation, $1,-540,350; loss incidental to European and Mexican wars, $240,000; net earnings applicable to dividends, $9,031,-565; preferred stock dividends, $6,017,450; common stock dividends, $2,000,000; surplus, $1,014,115.

The conditions of affairs in Mexico has operated to decrease the company's earnings. In August it appeared as though operations might be resumed at the Mexican smelters, but such was not the case. Conditions there continue to be a source of worry to the directors.

The total volume of the year's business was $200,-925,625, of which 4.49 per cent, or $9,031,565, was available for dividends. The value of the four principal products was: Gold, $52,515,548; silver, $42,-690,226; lead, $24,551,632; copper, $71,712,527. The company employs 12,179 men (excluding Mexico), and paid in wages $10,212,591.

Attention is directed to the diversity of the company's interests and operations. It is now refining and marketing gold, silver, lead, copper, zinc, nickel, platinum, arsenic, bismuth, cadmium, tellurium, selenium and palladium. It is also engaged in the manufacture of sulphuric acid and coke.

In welfare work the company has been active. The 3-shift, or 8-hour system has been adopted wherever practicable, less than 6 per cent of the labor working more than 8 hours. Wages have remained practically the same under the 8-hour system as when longer hours prevailed. Conservation of health of operatives and provisions for their safety have received attention. Life insurance has been taken out by the company in favor of the wife or family of the operatives, in the sum of $500 for unmarried men and $1000 for married employes. The pension fund now amounts to $520,238. During 1914 pensions were granted to 63 applicants, the average age of whom was 62 years.

The United States Smelting, Refining & Mining Co. shows in its ninth annual report, covering the calendar year 1914 earnings of all companies, $2,932,519; depreciation, $666,877; profit, $2,265,642; dividends, $2,-228,891; undistributed surplus, including surplus from previous year, $4,515,591.

Metals produced in 1914: Copper, 17,946,659 lb.; lead, 64,443,260 lb.; silver, 9,936,237 oz.; gold, 124,719 oz. The percentage in value of each metal was: Copper, 18.9 per cent; lead, 18.9; silver, 42.1; gold, 20.1.

The company has experienced the usual difficulties incident to the wars in Mexico and Europe. In April the company's American staff was obliged to leave Pachuca, Mexico. The Mexican staff remained on the ground and continued operations on a small scale. Expenses have been met, but no profit was made. No property damage has been done and the employes have not been molested.

The exploration department had presented for its consideration 639 properties. Of these 538 were rejected on an office examination of reports and data. A preliminary examination was made of 82, and 19 were accorded a complete examination. No purchases are reported. The company has been investigating the possibilities of oil fields in California, Wyoming and Mexico.

The American Zinc, Lead & Smelting Co. reports a total profit in 1914 amounting to $186,157, from which a net profit was carried to surplus account of $65,692. While conditions in the zinc industry were not satisfactory, nevertheless they were better than in 1913, when the company incurred an operating loss of $91,656. The European war, however, has made the United States the center of the spelter industry, and as long as the war lasts the price of spelter will be at a high figure. The company's smelters have a capacity of 110,000 tons of concentrates per annum and should produce 50,000 tons of spelter, about 11 per cent of the total output of the United States.

The mill at the Tennessee property has been increased in capacity from 1000 tons a day to about 1600 tons. Sufficient ore is in sight to supply 1800 tons a day for more than ten years. Only a single mill was operated in Missouri. The Wisconsin properties are producing at a much greater rate than ever before. The Hillsboro smelter has been in successful operation. The Dearing smelter was closed in 1914, and the Dearing plant operates at only 20 per cent capacity. An arrangement has been made, however, to treat a part of the Butte & Superior concentrates, and both the Dearing and Caney plants are ready to operate at 75 per cent capacity.

The Tennessee Copper Co. in its annual report for 1914 gives ore production as 468,668 tons, and estimated ore reserves as 4,010,661 tons. Material smelted during the year, in tons, was as follows: Tennessee copper ore, 437,340; converter slag, 17,909; blast furnace slag, 21,664; sinter, 42,909; limestone, 20,258; matte, 83,182; total, 724,822; coke, 38,726. Copper production was 12,871,113 pounds, at an operating cost of $0.1184 per pound. The average price received for copper delivered during 1914 was $0.13706 per lb. The production of 60° Beaume acid was 210,163 tons, an increase over that of 1913, due chiefly to improved smelting conditions. Net sales of all products amounted to $3,307,365; gross earnings, $981,900; net earnings, $805,455; dividends, $600,000; reserve for depreciation, $100,000; surplus for the year, $50,767; total surplus, $1,908,207.

The Nipissing Mines Company's report for 1914 states that the year was one of the most profitable in the history of the company. Silver production amounted to 4,689,333 oz.; gross value, $2,516,064. Net receipts were $1,587,621. Production cost was 19.8 cents per ounce of silver, being 4.29 cents per ounce less than in 1913. Average price at which silver was sold, 55.36 cents per ounce; in 1913 it was 60.26 cents, the decline being due largely to the war. Ore reserves amount to more than 10,000,000 oz. silver, an increase of more than 500,000 oz. over 1913. Surplus amounts to $1,602,776, an increase of $343,715. Dividends amounted to 20 per cent or $1,200,000. There was no change in treatment at the high-grade mill, which handled 929 tons of Nipissing ore of average value of 2439 oz. silver and 965 tons of custom ore of average grade of 2421 oz. silver per ton. The market for cobalt-nickel residue was good for the first half year, but was cut off by the war. The net income from 1060 tons of residue was $42,344. The low-grade mill treated 79,009 tons of ore of average grade of 30.82 oz. silver per ton. The actual recovery by clean-up was 89.64 per cent. Research work on the grinding operations showed that while practically all the rock in the final tube-mill discharge was finer than 200-mesh. metallic silver was flattened and would not pass. Two Callow screens have therefore been placed in the tube-mill circuits and are recovering from 20 per cent to 25 per cent of the silver in the ore. The dirty metallics are cleaned on a Wilfley table. Notwithstanding the increased cost of cyanide and other supplies, the total cost of treatment in the low-grade

mill was $0.14 per ton less than in 1913, amounting to $3.989, distributed as follows:

	Cost per ton
Crushing at mine	$0.128
Aerial tramway	.065
Surface tramway	.069
Picking plant	.204
Crushing and conveying	.048
Battery	.275
Tube mills and classifiers	.575
Desulphurizing and slime collecting	.304
Intermediate filtering	.111
Cyanide treatment	1.076
Cyanide filter	.138
Clarifying and precipitation	.288
Refining	.111
Heating	.118
Water supply	.036
Construction	.334
Residue dam	.059
Consulting	.050
	$3.989

The Iron and Steel Market

Buying of steel products suffered an abrupt reduction at the beginning of April by reason of the termination of a number of contracts written at lower prices than obtained in the corresponding contracts for the second quarter. In other lines the bookings have been undiminished. As the mills were fairly well provided with specifications operations have been continued through April at an average rate of about 70 per cent of capacity.

In bars, plates and shapes the placing of strictly new orders was somewhat discouraged by the advance of the mills to a basis of 1.20c. This was in accordance with a program announced by various large mills early in February, that their price would be 1.10c. for specifications to be filed during February, 1.15c. for March and 1.20c. for second quarter. Serious doubts were entertained whether the 1.20c. quotation would really become effective. The price was fairly well maintained in April, but the market was subjected to no serious tests by large inquiries.

The first half of April developing no new encouraging influences, sentiment in some quarters began to become less hopeful, but later in the month encouraging developments began to appear again. On April 20 the Lake Superior ore market opened, and the early sales were larger than had been expected. War orders were reported in greater numbers. The Pennsylvania railroad system announced a budget of $32,000,000 for the year, to cover new rolling stock, rails and track work in general, and while it was explained that this represented merely the limit of the possible expenditures the news was regarded as favorable and hopes were entertained that other railroads would be moved to enter the market also. The Youngstown Sheet & Tube Company, an important independent steel interest, made a large purchase of pig iron, although it was operating all of its four furnaces, this being the first large purchase of steel-making pig iron in the Pittsburgh district for months.

In the past few weeks the steel market has had two courses open to it. With no definite increase in consuming demand, and mills operating at only 70 per cent of capacity, it would be difficult if not impossible for the advances recently made in certain prices to be maintained, buyers would endeavor to restrict their purchases, and operations would probably eventually decline, though not to the exceptionally low rate of last November and December.

On the other hand, with a slight further increase in actual consumption mill operations would increase beyond 70 per cent, approaching rapidly the point at which deliveries of some products would fall behind, an occurrence that is always the signal for forward buying and for replenishment of stocks by jobbers and manufacturing consumers. The process is a familiar one in

the steel market, a fresh demand arising almost over night when the condition changes from one of buyers being able to obtain almost instant delivery against any specifications filed to one in which the buyer must wait a few weeks for complete delivery against a miscellaneous specification. Once the steel industry reaches such a condition, it is certain to operate at practically its fullest capacity for months. The gap to be bridged was not between 70 per cent and 100 per cent, but between 70 per cent and 80, 85 or 90 per cent, for after so long a period of restricted operations and with alien emigration in excess for a twelvemonth past it has been the general opinion that the steel industry could not open short notice operations at 100 per cent of its physical capacity.

The developments of the latter part of April have disclosed a decided balance of probability that the pendulum will swing in the direction of larger demand, resulting in forward buying, advancing prices and even, possibly, an actual "runway market."

Iron Ore

Since the Lake Superior iron ore interests abandoned their price agreement several years ago each season has been "opened" by one interest or another effecting sales, others immediately adopting the price level thus indicated. This year the first sales appear to have been made by W. P. Snyder & Company and selling at once became general. As had been expected for months, prices were the same as ruled in 1914 and 1912, 1913 prices having been 60c. to 65c. higher, as follows: Old range Bessemer, $3.75; old range non-Bessemer, $3; Mesabi Bessemer, $3.50; Mesabi non-Bessemer, $2.85 per ton 2240 lb. on Lake Erie docks, for 55 per cent ore in the case of Bessemer and 5150 per cent ore in the case of non-Bessemer. The prices are as low as have obtained at any time since 1904, and are really very low considering the royalties ruling and the cost of stripping large quantities of over-burden in the case of many operations. The net price of an ore is determined on a unit basis, 60 cents, an arbitrary freight adjustment, being added to the base price on dock, the total being divided by the number of units in the base ore. Thus the unit price on Mesabi non-Bessemer is approximately 6.7c. Between 50 and 53 per cent there is a straight adjustment, the unit price being increased above 53 per cent, while between 49 and 50 per cent the unit price is multiplied by one and one-half and between 48 and 49 per cent it is multiplied by two. Thus for 48 per cent ore—we are referring entirely to Mesabi non-Bessemer—the total deduction is five units or about 33c., making the net price on dock $2.52. The ore pays 60c. rail freight up to upper lake dock, 40c. vessel freight and 10c. dock charges, so that $1.42 would be realized at mines, a price which obviously affords profit only to mines operated under favorable conditions. Higher grade ores take care of themselves.

The opinion is expressed in ore circles that this season's movement down the lakes will be not less than 40,000,000 tons, against 32,000,000 tons in 1914 and 49,000,000 tons in 1913, the banner year.

Pig Iron

The spectacular movement in Buffalo pig iron, referred to a month ago, involved a total of more than 300,000 tons of iron, but on account of the low price at which the iron was sold, somewhat under $12 at furnace, the influence upon other pig-iron markets was depressing rather than stimulating and the pig-iron markets as a whole were decidedly quiet in April. There was, however, a fair movement in southern iron at $9.25, Birmingham, for prompt and at $9.50 for second half, while there was some fair buying of basic

in the east, chiefly at cut prices. It may be found that the purchases of the Youngstown Sheet & Tube Company, made ten days before the end of the month, will prove of considerable sentimental importance. This interest operates four furnaces, but buys merchant iron when operating its steel departments at above 75 or 80 per cent of capacity. It purchased from W. P. Snyder & Company ,Ohio Iron & Steel Company and Andrews & Hitchcock Iron Company about 40,000 tons of basic, 17,500 tons of forge and 5000 tons of foundry iron for delivery to October 1 at practically current prices. This is the first large buying in the Pittsburgh district since December and the first buying by a steel works having furnaces of its own for many months. The market is quotable as follows: No. 2 foundry: delivered Philadelphia, $14 to $14.25; f.o.b. furnace, Buffalo, $12.50 to $13; delivered Cleveland, $13.25; f.o.b. furnace, Chicago, $13; f.o.b. Birmingham, $9.25 to $9.50; at valley furnaces, 95c. higher delivered Pittsburgh: Bessemer, $13.60; basic, $12.50; No. 2 foundry, $12.75 to $13; gray forge, $12.50 to $12.75; malleable, $12.75.

Steel

Actual market transactions in billets and sheet bars have been light, consumers being well covered by contracts of various form. Specifications against these contracts have been steadily increasing. Prices are largely nominal at about $19 to $19.50 for billets and $19.50 to $20 for sheet bars, f.o.b. maker's mill, Youngstown, and about 50c. higher f.o.b. maker's mill, Pittsburgh. Rods are $25, Pittsburgh.

Finished Steel

Finished steel prices are fairly steady but in most lines the market has not been under much pressure on account of the existence of old contracts. Plates are being shaded, particularly in the Chicago district. Galvanized sheet quotations are largely nominal, some mills withdrawing entirely from the market, on account of the acute scarcity of spelter. Wire products have not developed a real market at the nominally advanced price and are quotable at the first of the two advances made early in the year.

Current quotations are as follows for ordinary deliveries and are f.o.b. Pittsburgh unless otherwise noted:

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.20c.

Shapes, 1.20c.

Steel bars and bands, 1.20c., base; hoops, 1.25c. to 1.30c.

Iron bars, 1.15c., Pittsburgh; 1.15c., Philadelphia; 1.15c., Chicago.

Sheets, blue annealed, 10-gage, 1.35c.; black, 28-gage, 1.80c. to 1.85c.; galvanized, 28-gage, 3.40c. to 3.50c.; painted corrugated, 28-gage, 2c.; galvanized corrugated, 28-gage, 3.45c. to 3.55c.

Tin plate, $3.20 to $3.35 for 100-lb. cokes.

Steel pipe, 80 per cent off list.

Steel boiler tubes (less than carloads) 3½-in. to 4½-in., 75 per cent off list.

Tennessee Copper Company's production of sulphuric acid has increased from about 600 tons a day to an average of over 700 tons, the maximum daily production having been 820 tons. Based on 350 operating days in the year, the annual production is at the rate of 245,000 tons of acid. It is reported that the profits derived from this phase of the business are sufficient to pay the entire dividends on $5,000,000 of outstanding stock.

The American Electrochemical Society in Its External Relations

BY F. AUSTIN LIDBURY

Presidential Address Before the American Electrochemical Society.

Eight years ago, when the American Electrochemical Society was last the subject of a presidential address,[1] the society was faced by many serious problems relating to its growth and the continuance of its existence. Finance, the provision of papers, the attendance at meetings, questions regarding publications, matters involving even its independence were the subject of anxious thought and discussion. The successful growth, both extensive and intensive, of the society since that time must be a matter of extreme gratification to those whose devotion, energy, and wisdom at an anxious period of its existence guided the society in the direction which has led to its subsequent well-balanced development.

There comes a stage in the development of every organization such as ours at which the cultivation of the primary objects of its existence no longer demands all its efforts; it becomes free to devote itself to external activities, and to represent its membership and what it stands for in the larger affairs of life. Of course, it need not do so. A voter need not exercise his franchise; but we do not call him a good citizen for the omission. An innocuous reputation for respectability and learning can easily be maintained by any scientific body which carefully avoids contact with objectionable external realities; but it is the kind of reputation which attaches to that paragon of respectability who "passed by on the other side." In the last few years this society has shown gratifying indications that it takes no such narrow view of its duties or its interests, and I hope and expect that its activities in external matters will be progressively intensified and broadened.

Perhaps as good an illustration as any of the direction in which our duties and our interests lie can be found by considering our relations to current tendencies in government. The extension of legislative and bureaucratic activities which the last few years have seen has been too widely regarded by intelligent persons as a manifestation which would play itself out, on the principle that "if the fool would persist in his folly, he would become wise." Not only has this optimistic expectation not borne fruit, but reliance on it has to a large extent prevented the offer of information and guidance from those in a position to give it. There are signs that men of business are realizing their mistake in the matter, and it is time that the man of science and the engineer also realized theirs. What cannot be averted can at least be guided into intelligent channels.

The engineer—take the word in its widest sense—has been worrying about these matters for a long time, and occasionally he comes to the conclusion that what is needed is representation of himself in legislative bodies.[2] He had better remember that legislation is really lawyers' business. If the scientific and engineering professions would worry less about their "status" and pay more attention to making their opinions heard and their recommendations respected, they would cease to be bothered about the undue proportion of lawyers in legislative bodies.

For, on the whole, these lawyer-legislators are not so scornful of information and advice as we are inclined to believe. They try to get both whenever they can, and, when the practical business man, the technical man, the engineer held aloof, they went to the university professor and, when he was not available, to the charlatan and the agitator. They have shown their power of discrimination by preferring the professor; they instinctively felt that he knew more. If his guidance has led them into difficulties, it is because his truths are too often colored by his theoretical idiosyncrasies and not founded on a pragmatic basis. Until we have given the legislator all the assistance in our power, we are obviously not in any position to accuse him of spurning it. Nor does it particularly matter if he does, for the power of an intelligent minority, however small, is tremendous, and there is no man more sensitive to well-informed criticism of sufficient publicity than your legislator unless it be your bureaucrat.

I have attempted to indicate the extent to which the intelligence of government of a democracy is dependent upon the coöperation of its intelligent elements, and the extent of the responsibility in this regard of those professions which claim to embody the application of intelligence to industrial operations. A little self-examination will show that a well-defined portion of this responsibility rests upon the American Electrochemical Society.

We need have no false modesty about it, either in regard to what we represent or to what we are. We represent a branch of the chemical industry whose products are of such importance to the general industries of the country that, in spite of its youth, its absence at the present time from among the industries of the country would cause such industrial disturbance that the plaint of the wearer of many colors, always imminent but not up to the present moment audible, would pass unnoticed.

As a society, we are unusually representative. We embrace in the personality of our members and in the scope of our discussions the practical as well as the theoretical, the commercial as well as the technical; as a consequence our organization is capable of considering all phases of any question which comes within its scope. We have had a healthy growth, and our functions are normal; we do not suffer from overgrowth or uncorrelated parts, nor are we weakened by the overdevelopment of any particular activity. We have a representative constitution and its consequence, a responsible and responsive management. Finally, we are entirely independent, not only of outside influences, but also of any one class of internal opinion; the diverse nature of our membership guarantees us against the dangers of a narrow point of view.

Our duties are proportional to our possibilities. It will not be necessary for us to look around for subjects to which to devote our attention; many of these are clear; on some we have already made a beginning, some, still more important, we have not had the temerity to touch.

Perhaps there is no subject which will better illustrate our sins of omission (in common, I hasten to add, with many technical bodies equally interested in the matter) than our inaction in regard to legislation concerning water power. This is not the occasion on which to discuss the limitations which have been imposed upon the development of power at Niagara Falls; nor if it were, should I be able to add anything to the treatment of the subject by my predecessor in his presidential address at the last New York meeting.[3] I wish not to touch upon the controversial aspects of that question, but to point out that we have allowed the whole matter to go by default.

A combination of fortunate circumstances enabled our industry to grow in the last twenty years to the point where we are somewhat more than independent of foreign manufactures in electrochemical lines. What we do not suffer from we do not realize, and while almost

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[1]Carl Hering, Trans. Amer. Electrochem. Soc., 11, 17 (1907).
[2]See, for instance, E. W. Rice, Jr., on the "Status of the Engineer." Proc. A. I. E. E., 34, 643 (1915).

[3]E. F. Roeber, Trans. Amer. Electrochem. Soc., 25, 17 (1914).

everyone who reads the newspapers is able to growl at the comparatively small development of the organic chemical industry in this country, an appreciation of what the same condition in the electrochemical industries would mean is probably not general, even among our own members.

It was not alone the reliability of Niagara power or its comparative cheapness which made it a vital factor in the development of our industries; it was the combination of these with a favorable commercial location. It is quite possible that had the development of power at Niagara Falls been prohibited from the beginning instead of throttled in its infancy the growth of electrochemical industries in this country might so have fallen behind that in other lands as to make us as dependent in this respect as, for instance, we are for dyes. We owe it to ourselves, both individually and as a society, to take every opportunity of bringing about a widespread knowledge of this situation. The electrochemical industry is already paying the penalty in the way of increasing scarcity of power and rising prices in the Niagara district, for allowing matters to take their own course.

Turning to the broader aspects of power development, we find that curious ideas have received governmental sanction, and even action, without any attempt at correction by us. For instance, that water-powers could be best developed by preventing people from developing them—we actually approved of this idea in a solemn resolution[4]; that conservation and the interests of the people and particularly efficiency would be best subserved by preferably connecting water-power plants to the loads of precisely the lowest load factors known.[5] If ideas of this description are acted on through lack of careful and intelligent controversion, who is to blame for the result—the ignorant, or those who know and keep silent?

I turn to patent legislation. Here we have, chiefly through the tireless energy of one of our past presidents, a record of some activity. But much more ought to be done. The combined efforts of many societies such as ours have succeeded in averting some very serious consequences of ignorance, but the whole question calls for a great deal of constructive effort. I know of no matter which presents to us so many difficult aspects, and not the least difficult is the danger that in trying to do justice to the "inventor" we may fall into the error (so common among inventors themselves) of regarding him as "the whole thing" So many of us have to take a matter where the inventor leaves off and make it work that we know better; we have a peculiar knowledge of this subject, and it is our duty to see that it is not overlooked.

We are governed more and more by commissions, officers and bureaus. Insofar as the operations of these agencies are of a restrictive nature, untoward results, where they occur, are usually due to ignorance being left to its own resources. A watchful readiness to extend co-operation, advice, information and assistance in matters which come within our scope will help to correct this.

It is likely, however, that we shall come more frequently in contact with agencies of a constructive nature, of which the scientific bureaus of the government may be taken as typical. These do a great work, and our respect and admiration for it is likely to be proportional to our knowledge of it. Their primary purpose coincides with our own, the assistance of the application of knowledge to industry. To a great extent their usefulness will depend upon us and our confrères in related lines, upon the use we make of them, upon the fertility

[4]Trans. Amer. Electrochem. Soc., 16, 3, (1909).
[5]Cf. Met & Chem. Eng., 11, 117 (1913).

of the suggestions they receive, upon the extent of the support of their efforts. It is so easy to take beneficial activities for granted that it is necessary continually to remind ourselves that a given amount of energy devoted to the support of existing valuable agencies will produce many times the results which would follow its application in other directions. The cultivation of many fields of investigation which would otherwise lie dormant because, being everybody's business, they are nobody's business, constitutes a peculiarly useful branch of governmental activity and we ought by suggestion and support to lend every possible assistance to those to whom it is entrusted.

The development of such relations with them would result in a duty of another description falling upon us as representing the people in these matters; in so far as such governmental activities touch upon our sphere, we should impose a measure of accountability. We should assist in checking expenditures on unnecessary work, or on duplication; we should insist, in view of the conception of bureaucratic infallibility held by the uninformed, on accuracy of statement in governmental publications, and of the elimination from them of collections of untrustworthy or incorrect information. We should carefully examine the recent tendency to regulate certain branches of industry nearly related to ours by instruction, by suggestion, even by the development of industrial processes.

Some aspects of this tendency are open to serious objections on principle; but it is evidently with us for trial at least, and we must do what is possible to encourage its useful, to discourage its harmful aspects. We should insist upon a careful checking of all statements of the commercial aspects of governmental work of this description as well as of its technical features. It is impossible to believe that governmental agencies such as I have alluded to could fail to gain in value by the inculcation of a sense of responsibility to the technical societies of the country. It would probably reduce the temptation to play to the gallery; it would at any rate prevent the deplorable spectacle of a member of the cabinet announcing a technical discovery originating in his department in terms of combined ignorance and extravagance of claim which would almost justify exclusion from the mails if employed by an ordinary company promoter.

Multiplication of instances in quite other fields of action would be easy; I have taken quasi-political cases because they afford perhaps the best illustrations, but I must turn, however, to the consideration of means, of the "adjustment of internal to external relations." The stimulus must come largely from the individual, the unofficial member. He must be ready to bring up subjects of general interest; the officers and the board must be equally ready to afford facilities for their general discussion and their thorough consideration by active and competent committees. However intense and unanimous the feeling of the membership may be upon any particular matter, the effectiveness of its expression will necessarily depend in the last resort upon the energy and ability of some committee. There is an unusual abundance of suitable committee material in this society, and there will be no difficulty in getting matters in which you are sufficiently interested properly handled. The discussion of external matters at our meetings would also tend to stimulate the exercise of the power of individual members for educating the uninformed.

Coöperation with other societies should be not only willingly given, but sought after. In general, coöperation with other societies forms an extremely important part of our external activities. Even the little which has been done has been productive of results. A single

joint meeting, for instance, with the Electroplaters' Association some years ago has not only led to a considerable increase in interest in electroplating work in our own society, but has given the impetus to some very interesting and promising developments in electroplating circles in more than one locality. But the most interesting steps in inter-society coöperation have been taken for us by our flourishing New York Section during the last few years. We are indebted to that Section and to its capable chairman for showing us to what extent many dominant subjects need joint sessions for their proper presentation and discussion; and that brings me to the suggestion that the encouragement of local sections is the readiest means of fostering a healthy internal and external development. By their very nature they are able to maintain a much more continuous chain of interest; they come more readily in contact with the problem of the moment, the external problem; they touch it with less hesitation, less formality.

I cannot conclude without expressing my admiration of the excellent example which the editor of "Metallurgical and Chemical Engineering" has set us in the editorial pages of his journal; pages which have often so thoroughly represented the society in external affairs that we may very well be pardoned, though not excused, for having felt any exertions on our part possibly superfluous.

Notes

The Caloris Company announces the removal of their factory from Philadelphia to Millville, N. J. There it is located along their own glass house so as to provide better facilities for handling orders for glass tubes, laboratory glass ware, etc.

The Oneida Community, Ltd., makers of the well-known Community Silver Plate, have completed and equipped a new factory at Kenwood, N. Y., and have now transferred the last of their various departments from Niagara Falls, N. Y., to this new plant. This move was made necessary to avoid the deleterious effects on the silver plate of the fumes from various chemical companies in the vicinity. It is said that the Niagara Falls plant which they have vacated is especially suitable for electrochemical work and may be leased on very advantageous terms.

The Buffalo Forge Company, of Buffalo, N. Y., has recently issued three interesting new catalogs. No. 200 relates to the "Buffalo planoidal fans," a modification and improvement on the older type of steel plate heating and ventilating fans with a comparatively small number of radial blades. With the improvements in design embodied in it, this type of fan is expected, for many conditions, to compete on an equal basis with the multiblade fans. Catalog 201 relates to "Niagara conoidal fans." Besides having all the advantages of the multiblade type in respect to higher operating speeds, more compact arrangement, and greater rigidity, the shape of blades and proportion to the housing used in the Niagara Conoidal, make it possible to convert into static pressure the velocity head, which is much higher proportionately to the total pressure with multiblade fans than with types having few blades. Catalog 182-E is a summary for convenient reference of the various types of blowers and exhaust fans, which are regularly built for direct connection to motors. This includes everything from large ventilating and drying fans down to the little Baby Conoidals for ventilation of moving picture booths, drying cabinets, etc., and electric blowers for single forge fires, which take less than half the horsepower of an ordinary electric lamp.

Hardinge Amalgamator.—The Hardinge amalgamator is a new invention of Mr. H. W. Hardinge, president of the Hardinge Conical Mill Company. While a full technical description is being withheld until the patents have been issued, the amalgamator is being tried in several Western mills. The adjoining diagram shows balls of gold amalgam (containing 50 to 60 per cent gold) from the Hardinge amalgamator
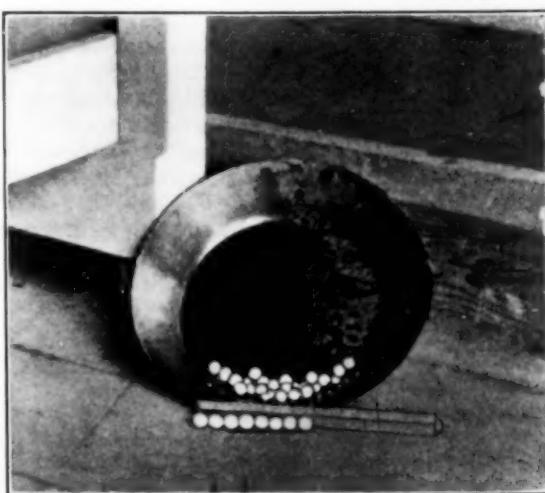
BALLS OF GOLD AMALGAM FORMED IN HARDINGE AMALGAMATOR

attached to the 8-ft. x 22-in. Hardinge pebble mill in the Plymouth Gold Mining Company's plant at Plymouth, California. These amalgam balls are formed by rolling around in the amalgamator and picking up small particles of gold in conjunction with mercury.

The Money Value of Radiated Heat.—In the Chamber of Commerce Building, Detroit, Mich., a retail store room is located directly over the boiler room and the heat from the latter was quite objectionable. In order to decrease the radiation of heat from the boilers and steam lines the engineer of the building insulated the settings and steam drums with Nonpareil Insulating Brick and recovered some of the steam lines and pump cylinders with Nonpareil High Pressure Covering. The cost of the Insulating Brick and Steam Covering was $214.84 and the application was made by the regular crew at odd times. Not only was the temperature above the boilers reduced 30 deg. by the use of this insulation, making conditions far more comfortable in the store above, but it was found that heat losses were reduced to such an extent that one boiler would carry the load which formerly required two. As the load in this plant varies but slightly it was an easy matter to obtain the fuel savings by comparing the records of coal consumption before and after the insulation was installed. In 1913, before the insulation was applied, the coal consumption in the six months from April to September was 224,960, 229,950, 218,790, 238,120, 224,-630, 211,490 lb. respectively or a total of 1,347,940 lb. For the corresponding period in 1914, after the insulation was installed, the consumption was 183,190, 181,-930, 180,690, 179,470, 176,000, 174,290 lb. or a total of 1,075,570 lb. This shows a net saving of 272,370 lb. of coal—136.185—tons costing $2.95 per ton. This is equal to $401.75 or over $800 per year—nearly four times the cost of the insulating materials, which were responsible for this saving.

The Spanish Government has prohibited the exportation of potash.

New Orleans Meeting of the American Chemical Society

Symposium on the Contributions of Chemistry to the Industries of the United States

The fiftieth meeting of the American Chemical Society was held in New Orleans, La., from Wednesday, March 31, to Saturday, April 3. Southern hospitality made the meeting a notable and highly successful and delightful event in the history of the society. The chairman of the local committees in charge of the different functions at the meeting were Messrs. W. L. Howell, C. S. Williamson, Jr., B. P. Caldwell, J. L. Porter, P. Asher, G. B. Taylor, L. A. Becnel, S. J. Tremoulet, and Mrs. E. J. Northrup.

The hotel headquarters were at the Grunewald Hotel, where many of the sessions were held. But the opening session, with the symposium on contributions of chemistry to American industries, was held in Gibson Hall, Tulane University, on Thursday morning, April 1. The attendance at this session was about 250.

President Charles Holmes Herty called the meeting to order and speeches of welcome were made by Mayor Martin Behrman and President Robert Sharp of Tulane University. President Herty replied for the Society.

Then Dr. Arthur D. Little of Boston, Mass., started the symposium with a very able address on "the industrial resources and opportunities of the South." The presentation of papers on contributions of chemistry to nineteen different American industries followed. The lecture by Dr. Bernhard C. Hesse of New York in the evening may be considered as the conclusion of the symposium. This lecture was delivered at the Hotel Grunewald.

CHARLES HENRY HERTY, PRESIDENT
AMERICAN CHEMICAL SOCIETY

SOCIAL FUNCTIONS AND EXCURSION

On Wednesday a smoker on the steamboat Sidney on the Mississippi river was greatly enjoyed by 300 members and guests including ladies. The cabin of the boat was festooned with smilax and gray Spanish moss. It was a very pretty Southland scene. A darky band furnished the music. Dinner was served. There was an entertainment afterwards and, of course, dancing. The party returned to New Orleans at 10 p. m.

On Friday evening a banquet was held at the restaurant de la Louisiane. The attendance was 200. Messrs. Alciatore served a real Creole dinner. Professor B. T. Caldwell of Tulane University was toastmaster and addresses were made by President C. H. Herty, Dr. W. L. Howell, Dr. C. L. Alsberg and Dr. C. L. Parsons.

There were some very interesting excursions during the convention week.

On Wednesday afternoon a party of 30 went through Henderson's sugar refinery.

On Friday afternoon a visit was paid to the New Orleans water purification plant by the Water, Sewage

& Sanitation Section. About 50 members were taken to the plant in automobiles.

On Saturday afternoon a party of 20 visited the sugar refinery at Chalmette, while another party devoted the whole of Saturday to an excursion to the Weeks Island salt mines. About 110 took part in the excursion. The hotel was left at 7.15 a. m. in special cars and a special train of the Southern Pacific was taken at Algiers depot. Drs. Baekeland, Herty, Hillebrand and Parsons were in the party. The island was reached at noon. It is a knoll or lump about 150 feet above gulf level. The party went down into the mine, 600 feet below the surface, 20 at a time. The area of the mine is at present 20 acres. No timber is used in the mine construction. The salt is blasted down—pure rock salt crystals of 99.99 per cent purity. There seems to be an almost unlimited supply. The Myles Salt Company operates the mine. The hospitality of the place was tendered personally by Mr. Beverly Myles. The party left the salt mine at 3 p. m. and reached New Orleans at 8 p. m. It was a delightful day.

SECTION MEETINGS

On Friday meetings of the different divisions were held all day long at the Grunewald Hotel and fairly well attended. 153 papers were presented.

There are now eight sections of the American Chemical Society as follows:

Agricultural and Food Chemistry, Secretary, G. F. Mason, H. J. Heinz Company, Pittsburgh, Pa. Chairman Floyd W. Robinson was in charge.

Biological Chemistry, Secretary, I. K. Phelps, Bureau of Chemistry, Washington, D. C. Chairman C. L. Alsberg was in charge.

Fertilizer Chemistry, Secretary, F. B. Carpenter, Virginia-Carolina Chemical Company, Richmond, Va. Chairman J. E. Breckenridge was in charge.

Industrial Chemists and Chemical Engineers, Secretary, S. H. Salisbury, Jr., Lehigh University, South Bethlehem, Pa. In absence of the chairman, G. P. Adamson, the proceedings of the section were in charge of H. E. Howe.

Organic Chemistry, Secretary, C. G. Derick, 619 Indiana Ave., Urbana, Ill., who presided in absence of the chairman.

Pharmaceutical Chemistry, Secretary, A. P. Sy, University of Buffalo, 24 High Street, Buffalo, N. Y. Chairman F. R. Eldred was in charge.

Physical and Inorganic Chemistry, Secretary, R. C. Wells, U. S. Geological Survey, Washington, D. C.

Water, Sewage and Sanitation, Secretary, Harry P. Corson, State Water Survey, Urbana, Ill. Chairman Edward Barton was in charge.

The Industrial Resources and Opportunities of the South

The symposium on Thursday was introduced by a fascinating address by Dr. **Arthur D. Little**, of Boston, Mass., on the industrial resources and opportunities of the South.

"Only those who have stood upon the seashore and there endeavored conscientiously to place the Atlantic Ocean inside a quart bottle by the aid of a teaspoon will appreciate the temerity and difficulties involved in an attempt to present within the compass of a brief address the industrial potentialities of the South. Probably no one but a relative stranger to the South would make the attempt at all.". . .

"The awful spectacle of a world in arms which we are forced to contemplate today must recall with peculiar vividness to many men and women North and South the horrors and desolation of another struggle which was concluded, happily as we all now believe, just fifty years ago. When we consider that the wealth of the whole United States in 1850 was estimated at a little more than $7,000,000,000 and that the cost of the war to the South has been conservatively figured at $4,000,-000,000, we may gain some faint notion of the material burden under which the South slowly arose to work out her destiny."

RESOURCES OF THE SOUTH

After giving some statistical figures, Dr. Little pointed out that agriculture is still and always will be the greatest business of the South and the backbone of its prosperity, although even now the value of manufactured products exceeds by nearly $90,000,000 the revenue from its farms.

ARTHUR D. LITTLE

As all the world knows, the South affords a peculiarly favorable habitat to the cotton plant and the 36,000,-000 acres under cotton produce annually from 14,000,000 to 16,000,000 bales of the fibre, or about 65 per cent of the world's crop. In this connection it may be said in passing that chemists by developing methods for utilizing values in the cotton seed have added from $12 to $14 per bale, or perhaps $200,000,000 yearly to the value of this single crop, so that the seed alone is now worth nearly as much as the entire crop of 1860. Cotton and seed together constitute about 30 per cent of the total value of Southern farm products, excluding live stock. The ultimate products of the cotton plant together constitute 30 per cent of the merchandise exports of the Whole United States. The value of staple, linters and seed in 1913 was $911,000,000. Corresponding values for 1914 were $704,000,000, so that the European war may fairly be said to have cost the South, on this one item, over $200,000,000.

Strangers to the South do not commonly think of this portion of our country as a manufacturing community. They may, therefore, well be surprised to learn that already the manufactures of the South greatly exceed in value the products of its farms and reach the stupendous total of more than $4,000,000,000. In the 29 years from 1880 to 1909 the capital invested in the South in manufactures increased 900 per cent and the value of manufactured products 407 per cent. The census survey of the entire country enumerates 262 different lines of manufacture. Of these 236 are already carried on in the South.

The annual value of Southern lumber is about $350,-000,000, but the reported cut excludes so many primary wood products of larger importance that at least another hundred million dollars must be added to represent their value and $25,000,000 more for naval stores.

Excluding lignite, the coal areas of the Southern states amount to about 88,000 square miles, or over 50 times the coal area of Germany, seven times those of Great Britain and twice those of all Europe, including Russia. The South's present proved reserves of coal are estimated at 530 billion tons, or 25 per cent more than the more thorough exploitation of all European countries has disclosed—and these Southern reserves comprise 75 per cent of all the coking coal in the United States. West Virginia alone has a far greater coal area than Great Britain and Germany combined, and she has mined less than 1/6 of one per cent of the 150 billion tons beneath her surface. Nevertheless, her 1912 output of 67,000,000 tons was 50 per cent more than all bituminous coal mined in the United States in 1880. Alabama already stands next to Pennsylvania in coke production.

With coal, limestone, and iron ore closely adjacent within her borders, Alabama has already demonstrated her ability to manufacture pig iron more cheaply than any other locality on earth and "he who has the iron will get the gold." Her present output of 2,000,000 tons is merely an earnest of her potentialities. The immediately available Southern iron ores are estimated at 2,600,000,000 tons, with even greater reserves of ores of lower grade. Together these constitute not less than 50 per cent of the total iron resources of the country.

It is doubtful if any American product is better known throughout the East than those tins of kerosene which bear the label of the Standard Oil Co. In 1890 the South produced less than half a million barrels of petroleum. In 1912 its output was 84,000,000 barrels. Passing by the great deposits of Louisiana and Texas, it may be pointed out that the oil production of Oklahoma alone in 1911 was 54,000,000 barrels.

More than 60 per cent of the natural gas output of the country must be credited to the South. About 5,000,000 hp in water power is available in the South and only about one-fifth of this power has been developed, and of this amount nearly 800,000 hp is in the five states of Alabama, Georgia, North Carolina, South Carolina and Virginia. Georgia alone has available 500,000 hp.

The lavishness with which Nature has bestowed her gifts upon the South is nowhere more apparent than in the extraordinary variety and range of what may be termed the secondary mineral resources of this fortunate section of our country. An output of $5800 worth of diamonds per week of the best South African quality in Pike County, Arkansas, is interesting and promises to become spectacular, but it shrinks to insignificance before many other Southern mineral products. The whole country knows the annual shipment of 8,000,000 boxes of Florida oranges and grapefruit, but relatively few of us give thought to the three million tons of the infinitely more important phosphate rock which Florida produces. This is about four-fifths of the country's output, practically all of which now comes from the South.

Portland cement requires for its manufacture an assured supply of limestone and clay or shale adjacent to cheap fuel. Nowhere are these conditions met more fully or more generally than in the South. As a result, its development of the manufacture of Portland cement has become one of the industrial miracles of the world. In 1890 the production for the whole United States was less than 400,000 barrels. In 1911 the output of cement in the Southern states alone was nearly 11,000,000 barrels.

Then the South has clays, gypsum, bauxite, sulphur. The largest sulphuric acid plant in the world is at Ducktown, Tennessee, but the striking feature of the installation which holds this record is that the acid is made from smelter fume, which commonly in other plants goes only to create a nuisance. The copper production, which is the primary output of the plant, is over 18,000,000 lbs. per year. The largest copper refining plant in the world is at Patapsco, Maryland, with an annual production of 200,000,000 lbs.

In 1911, 42 per cent of the lead output of the country came from the South and 41 per cent of the zinc production. The value of Missouri zinc alone was $14,000,-000. The largest pyrites producing plant in the whole country is in Louisa County, Virginia.

THE FAILURES OF THE SOUTH

What are the failures to be charged against the South? First of all, there is the stupendous failure of its agriculture. In 1909 only about 18 per cent of the total area of the South was tilled, whereas 75 per cent is available for tilled crops. What is more to the point, the 110,000,000 acres which were tilled were tilled badly.

Next, perhaps, in importance is the failure of Southern lumbering, which is one of the most wasteful operations conducted on the whole broad face of the Earth. Upon a cut of 30,000,000,000 feet of yellow pine the South wastes not less than 15,000,000,000 feet, which intelligently utilized as raw material should yield ten times the profit derived from lumbering.

Then there is the enormous waste in natural gas. The waste of gas in the Oklahoma fields alone has been as high as 150,000,000,000 cubic feet a year, and is now annually not less than 25,000,000,000 cubic feet. Every 100,000,000 cubic feet of natural gas represents on the basis of a ten-hour day 588,000 horse power, if consumed in a fair gas engine on fluctuating load averaging 50 per cent of rated capacity.

The South contains over 50 per cent of the total iron resources of the country. Nevertheless, it produces only $12\frac{1}{2}$ per cent of the pig iron made and consumes not over 150 lbs. per capita, while the figure for the whole country is 650 lbs. Here again we have before us the fundamental difficulty which confronts the South. A ton of iron ore shipped as ore returns only $2 and provides less than one day's work for one man. If shipped as stoves it returns $40 and has provided a day's work for ten men. The South has been selling raw materials. It should sell brain values and labor values.

Owing to its later advent as a large producer and its relatively more general introduction of by-product coke ovens, the South has been less wasteful than the North of the ammonia values in its coal.

An excellent example of intelligent conservation is afforded by the great pulp mill at Canton, North Carolina. Formerly the spent chips from the chestnut extract plants were burned. Now they are boiled in caustic soda and converted into high-grade pulp and paper.

One of the greatest of the relatively undeveloped potential industrial assets of the South is undoubtedly the negro. Scarcely any work carried on in the South today is more truly constructive or fraught with greater ultimate possibilities than that which goes forward at Tuskegee and in those other institutions of which it is the type.

THE GOAL OF THE SOUTH'S DEVELOPMENT

The first of the South's problems would seem to be the organization of rural life to make it richer, more satisfying, more profitable and pleasanter. It is bound up with the problem of the reorganization of Southern agriculture. *The South has really not begun to farm.*

Foremost among the industrial problems of the South would seem to be the suppression of wastes, the vastly greater development of labor values in its products and the keeping at home of money now needlessly spent elsewhere. The South has been too generally content with shipping crude materials and primary products and too ready to accept from other sections the things which it might better produce at home.

For gigantic wastes which may immediately be utilized to the enormous profit of the South no industry is comparable to the lumbering of yellow pine.

While Northern paper mills are paying on the average $18.37 for the wood to make a ton of paper, the South is throwing away tens of thousands of cords of pulp wood every day, only a cord and a half of which is needed to make a ton of Kraft paper, worth $70. The ultimate development of a vast paper industry in the South is assured. But men are needed—captains of industry.

"Several types of gas producer are now operating profitably on wood waste. New methods of controlled distillation have been developed and applied to wood, and it has been proved both by the Forest Service and our own laboratory that turpentine and rosin may be profitably extracted from stumps and lightwood by processes which permit the manufacture of paper from the extracted chips. The production of lumber in the South will ultimately become a mere incident in the business of lumbering. No longer then will logging tramways be pulled up the moment the saw logs on the tract have been removed. They will stay until the tract is cleared of cord wood, pulp wood, lightwood, stumps, and saw logs. The cleared land will be devoted to grazing or to farming under the stimulus of demonstration farms or corporation management and the lumber mill become the center of a whole group of highly profitable industrial activities.

"Less than 30 per cent of the lumber produced in any Southern state receives any further industrial handling in the state of origin. Cotton seed oil is shipped to Chicago and to Berlin, New Hampshire, to be hydrogenated and converted into lard and butter substitutes. Bauxite is sold for $5 a ton to be subjected elsewhere to the purifying treatment, which raises its value to $60. The South will one day benefit enormously by a cheap process of producing alumina direct from clay. It will give new values to Southern clay beds and to Southern water powers and transfer the aluminum industry to this section. It does not appear, however, that any effort is being made in the Southern states to develop such a process.". . .

"No locality in the United States, and perhaps none in the world, presents such advantages for the establishment of the great basic chemical industries as Louisiana. Here in close juxtaposition are found cheap salt, even cheaper sulphur, gas, oil, rosin, turpentine and wood waste, while nearby are the coal and minerals of Arkansas and Alabama.

"It is noteworthy, in view of the extraordinary opportunities for chemical development presented by the South, that in the Southern states are to be found only about 10 per cent of the chemists of the country as represented by the membership of the American Chemical Society.". . .

"Fragmentary and utterly inadequate as this attempted presentation of Southern resources has proved to be, it will have served its purpose if it has brought freshly home to some of you who live in this supremely favored section of our country the responsibility for individual initiative imposed upon you. Opportunity implies responsibility. Gentlemen, you are heirs to an imperial inheritance and its responsibilities are yours."

Contributions of the Chemist to Various American Industries.

After Dr. Little's very able address the symposium of papers on the contributions of the chemist to nineteen different American industries was begun. These nineteen papers were presented mostly by others than their authors. Dr. Baekeland read Mr. Ash's paper. The meeting adjourned at 12.30, when Dr. Horne's paper had been reached. Dr. H. A. Houston's illustrated lecture on the potash industry of Stassfurt occupied the afternoon session and the other papers of the symposium were presented on the next day in the convention hall at the Grunewald Hotel. Advance copies of the symposium papers were available. We herewith give a concise resumé of all of them.

Contributions of the chemist to the **California wine industry** were covered in a paper by **Charles S. Ash.** The chemist began to be of value to the wine industry only when he became familiar with the wine business and became a wine man. One of the chief problems he has solved is to assure the stability of the wine. Preservatives were first used, such as salicylic acid and benzoic acid, but the pure food laws have stopped this, and all attempts looking for a preservative that cannot be detected, have been in vain. But what the chemist has done in solving the problem of the production of a stable wine is the establishment of the fact that by proper methods of handling the use of preservatives becomes unnecessary. Further, by chemical control of the "blending" operation, he has insured the uniformity of the product as completely as seasonable difference will allow. Moreover, by chemical control, he has reduced the spoiled wine from 25 per cent to less than 1 per cent (about 0.46 per cent average). Finally he has reduced the quantity of inferior wine from 25 per cent to 5 per cent. (Some grapes always give inferior wine no matter what care is given to the products). In spite of earlier temporary discouragements, the wine chemist is now having more intimate relations to the wine industry.

The contributions of the chemist to the **copper industry** were the subject of a paper by **J. B. Francis Herreshoff,** vice-president of the Nichols Copper Company and consulting engineer of the General Chemical Company. The output of copper in the United States was 17,500 long tons in 1874; 64,708 in 1884; 158,120 in 1894; 362,739 in 1904; and 563,700 in 1912. It was not until after 1890 that the real value of chemists in improving operations in mining, as well as in concentrating, roasting, smelting, and refining copper was fully appreciated. Chemical analyses permit chemical control of concentration as well as of roasting and smelting. The United States mines produce more than 50 per cent of the copper of the world; 75 per cent of the copper of the world is refined in this country and the larger proportion of this refining is done by electrolysis. In carrying on this electrolytic work, the chemist has been responsible for a very large proportion of the improvements that have been made in the last 20 years. Copper wire for electrical purposes must be of highest purity such as can only be obtained by electrolysis; for instance, a quarter of one per cent of arsenic in copper cuts down its electrical conductivity from 101 to 45.

Contributions of the chemist to the **corn products industry** were discussed in a paper by **E. T. Bedford,** president of the Corn Products Refining Company. The industry of glucose and grape sugar, or, as it is known in this country, the industry of corn products, is based upon an epoch-making discovery of a chemist—the conversion by chemical means of starch into reducing sugars. Owing to the character of the raw material employed in this country—corn—the products are no longer limited to two; the chemist has added to them until their number now exceeds one hundred. The corn manufactured into corn products in this country amounts to 50,000,000 bu. per year. It is converted into 800,000,000 lb. of corn syrup, 600,000,000 lb. of starch, 230,000,000 lb. of corn sugar, 625,000,000 lb. of gluten feed, 75,000,000 lb. of oil and 90,000,000 lb. of oil cake.

The chemist soon recognized the large possibilities which lay in the utilization of certain constituents of the raw material which were allowed to run to waste. First among these were the nitrogenous substances, commonly classified under the name of "gluten." Their running to waste was dropped; the product was collected, washed and dried, and put upon the market as a cattle feed. The recovery of the outer hull of the corn, the bran, and the development of the corn oil industry followed.

Contributions of the chemist to the **asphalt industry** were the subject of a paper by **James Lewis Rake,** secretary of the Barber Asphalt Paving Company. Chemistry, in the service of the asphalt industry, has converted it from one which originated on purely empirical lines into one which is now founded on a rational and highly scientific basis. The chemist has given his assistance in the preparation of fluxes or heavy oils of suitable character, and in the fixing of a standard for the grading of the sand and the nature and amount of filler or powdered stone which enter into an asphalt pavement. Aside from this, he has studied the nature of the native bitumens which are the components of asphalt and has differentiated the various types which are found in nature. In fixing the characteristics of the asphalts and the various petroleums from which fluxes and residual pitches are obtained, he has made it possible to describe these materials with such accuracy in specifications that they are readily differentiated.

The contributions of the chemist to the **cottonseed-oil industry** are covered in a paper by **David Wesson,** manager of the Technical Department of the Southern Cotton Oil Company. The industry was started in the fifties of the last century by one or two mills in New Orleans. In 1872 as much as 52,705 tons of seed were crushed. This amounted to 4 per cent of the entire crop of 1,317,637 tons. In 1913, with a production of 6,305,000 tons 4,767,800 tons were crushed, or 75.6 per cent of the entire crop. The estimated average cost per ton was $25.35, and the total value of the seed alone was $120,850,000, while the value of the products was $156,600,000. About 1890 "chemistry began to take the industry in hand. Crude oil, up to now, had been bought and sold as prime, or prime for the season, or off, and was passed upon by manufacturers and brokers, who looked at it, tasted it, then looked wise and gave their verdict. Then the chemist stepped in and found that the quality of the oil closely followed the free-acid present, and started grading accordingly. This made a big stir. Some of the mill owners denied the possibility of free fatty acid being present in any of their oil, as they never had any fatty acids on their premises. The chemists then showed these same mill men how much oil they were losing in their cake and throwing away in their hulls, with the result that more oil was made per ton of seed.

"The hulls were burned under the boilers and furnished the power for the mills. Every ton of seed furnished about 700 lb. of hulls. The ashes, averaging about 10 lb. per ton of seed were a valuable by-product, being rich in potash and phosphoric acid.

The writer is in doubt whether it was a chemist or a cow that discovered that hulls were good for cattle food. At any rate, cows ate them with avidity, and analyses proved that they had the feeding value of low-grade hay. So the mills now get from $4 to $10 a ton for hulls which were worth about $1 to $2 per ton as fuel.

"The cotton-seed soap stock in the early days was almost thrown away. Much was made into woolen and scouring soaps. About 1877, a bright near-chemist mixed some of this soap with soda ash, and made it into washing powder. The advertising man made a virtue of its yellow color, and the 'twins did the work.' Now, the soap stock is used as a source for white distilled fatty acids and glycerine, while the residual tar from the stills forms a base for paint and roofing materials."

But the chemist's greatest service to the industry has been in the refining of the oil. His achievements are summed up as follows: He has put the refining of crude oil on a more rational basis and prevented loss in manufacture by making a physical audit by analytical methods of the work of mills and refineries. By analyses of products their values have been shown, and the commercial practice has been placed on an accurate foundation. By improving refining methods, practically all cottonseed oil, regardless of section, or season, has been converted into one of our most valuable food products, and the residue worked into valuable by-products. By the new process of hydrogenation wholesome edible fats of the consistency of butter and lard are now produced entirely from what will probably continue to be our cheapest vegetable oil. While the chemist has worked to improve the manufacturing side of the industry, he has been the means of putting something like $125,000,000 every year in the hands of the farmers; or, in other words, he has added ten to twelve dollars to the value of the crop for every bale of cotton grown and has made possible an industry which provides means of livelihood for the thousands of people in hundreds of factories and on the road making and selling the products.

Contributions of the chemist to the **cement industry** were the subject of a paper by **G. S. Brown**, president of the Alpha Portland Cement Industry. "The tremendous advance made in this industry has been, for the most part, due to the zeal and knowledge of the chemist." Portland cement has been manufactured in Europe for very many years and in the latter part of the nineteenth century was imported into the United States in large quantities. Then by chemical research it was established that with the materials available in this country it was possible to manufacture cement really of a better quality than that hitherto imported. A broader field was opened by reduction of the cost in manufacture, due to the use of powdered coal as fuel, the increase in the size of the kilns, and the handling of the raw material in large quantities direct from the quarry. Further work has been done by the chemist in the working out of standard specifications, in the development of a water-proof cement, etc. "The fact that the chemist is responsible for the quality of the cement to such an extent that he controls the operation of the mill, is largely advertised by at least one of the larger cement manufacturing companies in the United States."

Contributions of the chemist to the **sugar industry** were discussed in a paper by **W. D. Horne**, who reviewed the past, present and future. In the manufacture of raw sugar, the past quarter century has seen great advance through bringing factories under chemical control, and the cane industry has caught up with and surpassed the beet industry through its scientific development on these lines. The consumption of sugar in the United States has risen from 1,500,000 tons in 1890 to 3,750,000 tons in 1914 and the per capita consumption from 54 lb. to 84 lb. per year. This has been partly due to the cheapening of sugar through scientific management in its production, raw sugar having fallen from 2.88 cents per lb. (without duty) in 1890, to 2.03 per lb. in 1914, and this, too, in spite of a rise in price of all other food staples, averaging considerably over 15 per cent.

In making raw sugar the proper defecation and clarification of the juice are chemical matters of first importance and during twenty-five years great improvements have been made in the double carbonation process both for beet and cane, the use of sulfitation of the thin carbonated juice, and the use of phosphoric acid and its salts as additional defecating materials. Kieselguhr has been introduced by Wiechmann as a clarifying agent and is now being used more and more extensively, especially since the development of the great Lompok deposit in California. Raw sugar factories are now producing white sugar directly from cane as well as from beet, due to chemical investigations of the matter and chemical control.

Raw sugar factories are now generally able to sell their molasses instead of throwing it away, because of chemically developed methods of converting it economically into alcohol, cattle foods when mixed properly with bagasse, peat moss, etc., and into other useful products. The sugar is all recovered from beet molasses by the Steffens process of conversion into tricalcium saccharate, and the by-products from this are going into fertilizers, cyanides, etc. Wax is recovered from scums and the residues utilized as fertilizers in the cane fields. Paper is made from the unused fiber of the cane and another by-product has been improved by the chemical investigations of the manufacture of rum.

In sugar refining, due to chemical research, invention and control, progress has been made all along the line. This and another work done in many laboratories is concisely sketched in the paper and the author concludes that the future contributions of chemistry to the sugar industry will probably be found in simplified processes of defecation, cheapened materials for color removal, etc., more energetic chemical treatment of low-grade products and a better utilization of such by-products as are inevitable.

The contributions of the chemist to the **incandescent gas-mantle industry** were discussed in a paper by **Sidney Mason**, president of the Welsbach Company. "No article more strikingly emphasizes the importance of the science of chemistry than does the incandescent gas mantle, which owes both its inception and development, up to the towering output in the United States alone of upwards of 80,000,000 mantles annually, to the untiring effort of chemical research." The paper was naturally a concise summary of the work of Auer von Welsbach and his coworkers.

Contributions of the chemist to the **textile industry** were discussed by **Franklin W. Hobbs**, president of the Arlington Mills, and past president of the American Cotton Manufacturing Association. He sketched the contributions of chemistry to bleaching, dyeing, the production of dyestuffs, mercerization of cotton, and manufacture of artificial silk. "The annual production of artificial silk is now fully 20,000,000 lb. There are various processes—collodion, gelatine and viscose. The viscose process now seems to command the field and is developing rapidly in quantity and

quality produced. Here is a case where common wood pulp worth a few cents a pound, by a touch of the chemist's art, is changed to a beautiful silk-appearing yarn worth from $2 to $3 a pound."

Contributions of the chemist to the **fertilizer industry** were discussed in a paper by **H. Walker Wallace,** manager of the general sales department of the Virginia-Carolina Chemical Company. The chemist discovered the necessity of the industry by studying the composition of soils and plants. He first suggested the production of superphosphate and established its manufacture. The process of manufacture has been gradually improved so that the insoluble phosphoric acid has been reduced from two to three per cent to a fraction of one per cent. He was responsible for the manufacture of sulfuric acid, which is necessary for the production of superphosphate. He has produced a double superphosphate containing from 45 to 50 per cent available phosphoric acid. His researches have made it possible to convert many waste products into valuable plant food constituents, which are utilized in fertilizers. The nitrogen of the air has been combined and converted into forms suitable for plant nutrition. The chemist has worked out processes for saving the nitrogen in flue gases and coke ovens and converting it into sulfate of ammonia. He has worked out formulas and blended the various fertilizer constituents into the compounds best suited for different soils and crops.

Contributions of the chemist to the **soda industry** were discussed in a paper by F. R. Hazard, president of The Solvay Process Company. The role of the chemist in industrial operations is to answer the question "why?" The chemist is the enemy of rule-of-thumb methods. He is not content to accept the superstitions and prejudices which have been handed down in all industry, but seeks to ascertain the causes underlying the effects which, in some cases at least, are produced with a considerable degree of regularity by the rule-of-thumb methods. It is only within the past twenty-five or thirty years that the chemist has been admitted as an important member of the manufacturing staff in our modern industrial life. Formerly the managers and owners of the business knew very little about the practical operation. They relied upon the secret formulas of the foreman. It is easy to see that the advent of the chemist was attended with great difficulties. He was regarded as their natural enemy by superintendents, and was looked upon with distrust by workmen. His experiments were ridiculed and not infrequently were purposely interfered with, so that their results would be without value. Thus early in his introduction into the industrial field, it became absolutely necessary for the chemist to tell the workmen, the superintendent, the manager, or owner, that none of them really knew their business, which unfortunately was the fact. . . . "The chemist must, therefore, exercise the patience of Job, he must have the wisdom of the serpent and the gentleness of the dove; he must be persevering and constantly alert to see the first signs which will lead him toward the answer to his question."

"As an illustration of the delicate position of the chemist toward the manufacturer, the following is taken from our own experience: About twenty-five years ago a soap-maker complained that 58 per cent alkali purchased from us was not as good for his purpose as 48 per cent alkali imported from England. After considerable correspondence it developed that his method of ascertaining this peculiar fact was to take, say, 100 lb. of each quality of alkali, dissolve each by itself in about a barrel of water and then determine the specific gravity of the solution by means of a Twaddle hydrometer. The 48 per cent alkali gave a somewhat greater specific gravity and he thereupon concluded that it was a superior article. As he was one of our important customers and a somewhat difficult man to deal with, it became necessary to convince him by his own methods that his conclusions were not correct. We prepared samples of several different kinds of alkali, also of common salt and of sulfate of soda, and, using the same hydrometer, we determined the density of each, whereupon it was found that on his theory it was an absolute waste of money for him to purchase alkali of any kind, as ordinary commercial sulfate of soda showed a considerably greater specific gravity than any of the other solutions. When confronted with this actual test, made on the same scale and using the same instrument as he had been accustomed to employ, our customer acknowledged, and continued for many years thereafter to make his soap by the use of our 58 per cent alkali." . . .

"Only last year, to show that the knowledge which a chemist can contribute is still of value, a complaint was made by a glass-maker that the 58 per cent alkali furnished to one of his works was inferior to that furnished at another. Correspondence developed the fact that the workmen at one point were also employed in handling lime and that the ventilation of the plant was not very good, while the conditions at the other plant were much better. The chief complaint was that the men in the one plant suffered seriously from sores; in fact, some of them were quite disabled. A personal investigation by one of our representatives showed that the unfortunate men were employed first in handling lime and then in unloading alkali, which was in bulk. The weather being quite warm and the exertion by no means easy, these men were establishing upon their own persons miniature caustic soda plants, and the resulting soreness and tenderness of the skin, if neglected, as was too often the case, led to rather serious conditions which required a long time to heal. An elementary knowledge of chemistry would have been sufficient to ascertain the cause of the difficulty."

Contributions of the chemist to the **leather industry** were the subject of a paper by **William H. Teas,** president of the Marion Extract Company. The author sketched the work of the chemist in preparing and using the different vegetable and mineral tanning materials.

Contributions of the chemist to the **flour industry** were the subject of a paper by **John A. Wesener** and **Geo. L. Teller.** The authors concisely summarize the principles of flour making. Chemistry assists in selecting and buying the grain; it helps to show the quality of the flour produced. It has supplemented mechanical processes of the mill and accomplished what had long been desired but could not be attained, in the improvement of color and baking qualities of the flour. By the introduction of baking-powder products it has made possible many delicacies in the way of pastry and biscuit and has made possible the great self-raising flour industry. It has helped to explain the intricate process of the fermentation of bread dough, has pointed out the way to fit flour for it, and has unlocked for investigating problems of bread production, which have, as yet, opened only enough to permit a glimpse of a large space filled with interesting and useful possibilities.

Contributions of the chemist to the **brewing industry** were discussed in a paper by **Gaston D. Thevenot.** In brewing biological considerations are as important as chemical ones. The influence of the

chemist makes itself felt first in the selection and preparation of the raw materials from which the beer is made. An enormous amount of energy has been expended by the chemist on the explanation and scientific control of the mashing process and great strides have been made in this field. The progress made in the fermentation of the beer during the last decades has been of the first magnitude. As far as the finished product is concerned, its clarification and sterilization have been given great attention. The problems of the disposal of former waste materials (spent grains, carbonic acid gas, yeast) have also been solved by the chemist.

Contributions of the chemist to the **preserved foods industry** were discussed in a paper by **R. I. Bentley**, vice-president and general manager of the California Fruit Company Association. A little over a century ago Appert, a French chemist, was awarded a prize by his government for discovering a process for preserving foods without the use of preservatives. Appert's process of hermetical sealing is the same in principle as that in use today by food preservers the world over. But the industry has grown to enormous proportions. New York City expends $150,000,000 annually for preserved foods—as much as that city spends for milk, bread and eggs combined for the same period.

Chemistry has enabled the food preserver to get the best materials suited to his use. A very simple illustration is that of salt—used to a large extent in the preservation of vegetables. Formerly, the preserver considered it a matter of economy to use the cheapest grade of salt that could be purchased. The chemist has shown him that some salt on the market contains injurious materials and that its use affects both the quality and appearance of products. Chemistry having already determined what grade of salt is best suited to his use, on its delivery the chemist determines whether the preserver has received what was selected. In the item of solder also, chemistry has enabled the preserver to get those proportions of metals which are best suited to his use, and on delivery the chemist tells him whether he has received what he ordered.

The services of the bacteriologist, besides the chemist, are needed in the food preserving industry to determine the best methods of processing. Among the applications of chemistry that have given the food preserver an improvement in the quality of his products is the improvement in the color of some varieties of fruit, such as berries, by the enameling of the inside of the can; also the examination of the water supply of the food preserver and the elimination of the objectionable elements in the water or the securing of a new supply. The almost complete elimination of iron in the machinery which comes in contact with the canner's products is due to the chemist pointing out the fact that the source of darkening or discoloration of the products was caused by the affinity of iron for tannin.

Chemistry has enabled the preserver to arrive at more economical methods of manufacture, particularly in the saving of labor and eliminating or reducing waste. Many fruits and vegetables are made ready for canning by immersing them for a few seconds in a solution of caustic soda, after which the fruits or vegetables are subjected to the action of fresh water sprays. In this manner the peeling is removed at a great saving in waste and labor without affecting the flavor of the fruit and vegetables so treated. By this method riper, and consequently better-flavored fruit can be handled than by the hand method of peeling. This method is now used almost

exclusively on some varieties and is far more cleanly and sanitary than the old.

The most notable application of chemistry in the matter of utilizing the by-products of a food preserver is that of the pineapple waste in the Hawaiian factories. The sugar value in the waste is recovered and a syrup furnished to the preserver, whereby the use of cane sugar is almost entirely eliminated.

Contributions of the chemist to the **potable water industry** was the subject of a paper by **Wm. P. Mason**, professor of the Rensselaer Polytechnic Institute. The author sketched the development of the ideas as to what is required from a chemical analysis of potable water, and pointed out why in a large municipal filter plant a chemist and bacteriologist is continually needed on duty to prevent "pin-point coagulation" or an overdose in the use of "bleach," etc. To arrive at a complete estimate on the value of a water the chemist's knowledge is needed besides that of the bacteriologist.

Contributions of the chemist to the **celluloid and nitrocellulose industry** were the subject of a paper by **R. C. Schüpphaus.** All the applications of nitrocellulose in the arts are based on the fact that the structure of its various forms may be broken down by the action of suitable solvents. The discoverer of nitrocellulose was already in possession of its colloid solution. The differences between soluble and insoluble varieties (in certain solvents) were quickly recognized, and representatives of four great groups of solvents were known at the very dawn of the nitrocellulose industries, viz.: 1. Alcohols: Methyl and ethyl alcohols. 2. Ester: Methyl and ethyl acetates. 3. Ketones: Acetone. 4. Mixed solvents: Ethyl alcohol and ethyl ether.

With these fundamental facts to start from there began a long line of chemical activity. Among the industries developed, the manufacture of pyroxylin plastic occupies the first place, and the other developments, such as the production of photographic films, artificial leather, pyroxylin varnishes, and even artificial silk made from collodion may be regarded as offshoots from this branch. The activity of the chemist in this industry is twofold, covering research and control of operations. This is sketched somewhat more in detail in the paper and it is pointed out that there is not a factory of pyroxylin compounds of any importance in existence today that has not its busy staff of analytical, managing and research chemists.

Contributions of the chemist to the **glass industry** were discussed in a paper by **A. A. Houghton**, vice-president Corning Glass Works. Chemical research on glass was first necessitated for glass for optical purposes. The glasses originally available for optical purposes were made up of only five oxides—silica, potash, soda, lime, and lead oxide. Doebereiner (1829) introduced barium and strontium, Harcourt (1834) experimented with twenty other elements, and Otto Schott, since 1880, did very extended work on special glasses in conjunction with Professor Abbe and the Zeiss Company. Schott first used boric acid in glass, which is of greatest importance for optical glass. He developed not only optical glass, but thermometer glass, borosilicate glass for lamp chimneys, a compound glass for boiler water-gauge tubes, the Uviol glass for transmitting ultraviolet light, etc.

"America's contribution to the development of the glass industry, chiefly in methods of working and handling the molten glass, are epoch-making in character; along more strictly chemical lines creditable work has been done, as instanced by the Tiffany or Aurene glass, the selenium red, and others. Aside

from optical glass, on which a beginning is being made, the glasses produced in this country probably are fully equal in quality and variety to those produced abroad; and in some respects America is forging ahead."

Contributions of the chemist to the **pulp and paper industry** were the subject of a paper by **F. L. Moore,** president of the American Paper and Pulp Association.

It is hardly too much to state that the development of modern paper making and the enormous extensions of the use of paper in recent times have been due for the most part to the introduction of the three chemical processes by which wood fiber has been made available as a general substitute for rags. The author sketched the development of the sulphite process (which has now reached in the United States a production of over 5000 tons a day), the soda process, and the sulphate process, and pointed out how the paper and pulp industry has been vitally influenced by the new processes yielding cheap alkali and cheap bleaching powder, and other chemical inventions.

This paper concluded the symposium.

The Contribution of the Chemist to the Industrial Development of the United States

Dr. **Bernhard C. Hesse,** in a lecture entitled "The Contribution of the Chemist to the Industrial Development of the United States—A Record of Achievement," summarized the results of the chemist's work, brought out in the nineteen papers of the Symposium. For twelve of the nineteen industries covered in the Symposium the number of wage-earners and the value of manufactured products and the value added by manufacture is given in Table I*a* for the year 1909. For eighteen additional industries which make use of chemists in the control of their operations the corresponding figures are given in Table I*b*.

For these thirty-one industries, the 0.01 per cent of chemists of our population directly affect 16 per cent of our wage-earners, 24.6 per cent of our manufactured values and 20.2 per cent of our values added by manufacture. This is a measure of the influence of the chemist upon the industrial development of the United States as a nation.

BERNHARD C. HESSE

Table II gives a summary of the export trade between the United States and Germany for twenty-nine industries. The industries in which the United States is importer from Germany are given on the left hand of the table, those in which the United States is exporter on the right hand.

It is interesting to note that we sell Germany more lard than Germany sells us of potash and aniline and other coal-tar dyes put together; that we sell Germany half again as much refined petroleum as it sells us aniline and other coal-tar dyes; that we sell Germany practically the same amount of pig and scrap lead as Germany sells us of alizarin and anthracene dyes; that we sell Germany almost as much paraffine as Germany sells us of indigo, and so on through the list.

As a rule the things that we sell to Germany are from a chemical point of view, less refined, i. e., involve

TABLE I*a*	Wage-earners	Product value	Value added by manufacture
Wine	1,911	$13,120,846	$6,495,313
Copper	15,628	378,805,974	45,274,336
Fertilizer	18,310	103,960,213	34,438,293
Textiles	44,046	83,556,432	48,295,131
Canned and preserved foods	59,968	157,101,201	55,278,142
Cotton-seed oil	17,071	147,867,894	28,034,419
Cement	26,775	63,205,455	33,861,664
Sugar	20,730	327,371,780	52,523,806
Brewing	54,579	374,730,096	278,134,460
Leather	62,202	327,874,187	79,595,254
Glass	68,911	92,095,203	59,975,704
Paper and wood pulp	75,978	267,656,964	102,214,623
Chemicals (strictly)	23,714	117,688,887	53,567,351
Totals	529,823	$2,455,035,132	$897,688,496

TABLE I*b*			
Iron and steel	278,505	$1,377,151,817	$399,013,072
Petroleum refining	13,929	236,997,659	37,724,257
Lead smelting and refining	7,424	167,405,650	15,442,628
Illuminating and heating gas	37,215	166,814,371	114,386,257
Confectionery	44,638	134,795,913	53,645,140
Paint and varnish	14,240	124,889,422	45,873,867
Soap	12,999	111,357,777	39,178,359
Carpets and rugs	33,307	71,188,152	31,625,148
Explosives	6,274	40,139,061	17,328,113
Zinc smelting and refining	6,655	34,205,894	8,975,893
Turpentine and rosin	39,511	25,295,017	20,384,174
Oil cloth and linoleum	5,201	23,339,022	7,788,921
Chocolate and cocoa	2,826	22,390,222	8,867,162
Baking powder and yeast	2,155	20,774,588	11,436,603
Dyestuffs and extracts	2,397	15,954,574	6,270,923
Blacking, cleansing and polishing preparations	2,417	14,679,120	7,716,728
Wood distillation other than turpentine	2,721	9,736,998	3,861,147
Oleomargarine	606	8,147,629	1,650,997
Totals	513,020	$2,605,262,886	$829,052,389
Total for 31 chemical industries	1,042,843	$5,060,298,015	$1,726,740,885
Total for all industries	6,615,046	$20,672,051,870	$8,529,260,992

TABLE II—U. S. CHEMICAL TRADE WITH GERMANY (1913)		
U. S. imports from Germany	Value in U. S. money	U. S. exports to Germany
	$75,000,000	1 Copper
	26,700,000	2 Lard
1 Potash salts	18,819,000	
	12,690,000	3 Refined petroleum
2 Aniline and other coal-tar dyes	7,290,000	
	4,970,000	4 Phosphate rock
	4,880,000	5 Oleomargarine
	4,585,000	6 Turpentine rosin
	4,460,000	7 Mineral lubricants
	3,840,000	8 Spirits turpentine
3 Caoutchouc	2,582,000	
	2,220,000	9 Crude benzine
	2,171,000	10 Beef tallow (prime)
	1,744,000	11 Nickel and nickel coin
4 Straw, esparto and other fibers; paper stock	1,649,000	12 Cotton-seed oil
	1,550,000	
5 Alizarin and anthracene dyes	1,463,000	
	1,421,000	13 Pig lead and scrap
6 Indigo	1,319,000	
	1,231,000	14 Crude and hard paraffine
	1,162,000	15 Acetate of lime
7 Platinum and allied metals	1,120,000	
8 Hops	952,000	
9 Miscellaneous volatile oils	941,000	
	903,000	16 Tin and tin scrap
10 Tin and tin scrap	900,000	
11 Potassium and sodium cyanide	845,000	
12 Chrome, tungsten, etc.	784,000	
13 Superphosphates	766,000	
	724,000	17 Crude wood alcohol
14 Beet sugar, refined	716,000	
	695,000	18 Carbides
	673,000	19 Miscellaneous volatile oils
15 Alkaloids exoquinone	672,000	
16 Toilet and tooth powders	658,000	
	656,000	20 Heavy benzine and patent naphtha
17 Lime-nitrogen, etc.	635,000	
18 Potash carbonate	632,000	
	617,000	21 Lubricants of fats and oils
	579,000	22 Beef and mutton tallow
19 Ferro-Al, Cr, Mn and Ni	567,000	
20 Potassium magnesium sulfate	509,000	
21 Gold ores	506,000	
	506,000	23 Copper alloys
22 Beet sugar, raw	492,000	
23 Aniline oil and salt	476,000	
24 Bronze and metal colors	473,000	
25 Glue	471,000	
26 Aluminum plates and metal	454,000	
27 Quinine and its salts	436,000	
	422,000	24 Portland cement
28 Terpineol and allied synthetics	409,000	
29 Gelatin	403,000	

less hard chemical intellectual work than do our imports from Germany. But this is so in our whole export and import business, not merely in chemistry.

With the record of which he has accomplished the American chemist can hold up his head with pride and self-confidence. That he has not done more is by no means due to any unwillingness. It is due in the largest part to the apathetic attitude of those in charge of the management of many of our industrial enterprises requiring chemical knowledge in their exploitation. Many of them fail absolutely in a chemical understanding of their own products and are devoid of any sympathetic contact with chemistry and with chemical points of view and therefore are incapable of, and unable to appreciate the value of chemical work or to have a wholesome understanding of the snares, the pit-falls and the tedium of chemical research.

The plea for the wider introduction of chemists into positions of managerial responsibility is, however, not to be interpreted into a statement that any kind of a chemist can do any kind of a chemical job. "In selecting your chemist for a responsible position you must look out that you do not get a square peg for a round hole, just as you would when engaging a man for any other position, but the trouble seems to be with many of those who have engaged chemists that they have not appreciated that there are chemists and chemists; they seem to have some sort of an idea that there is a magic about what a chemist does. Now, there is no magic at all. It is all plain, hard work, that calls for a lot of intellectual effort, and above all, the application of common sense which as every one knows, is a very rare article."

The second part of the lecture dealt with the criticisms of the American chemist which have been made by the daily press since the beginning of the European war on account of the fact that there is no complete American dye-stuff industry.

Broadly considered, the criticisms of the press may be grouped as follows: (1). The present shortage of dyes and inaccessibility of German producers to the American market offers an unusual opportunity for the manufacture of coal-tar dyes in this country. (2). The chemical manufacturer of this country should make those coal-tar dyes.

As to the first question, Dr. Hesse point out that there is no real shortage.

As to the second question Dr. Hesse referred to Lord Moulton's reasoning that one dollar's worth of dye-stuffs is necessary to the production of $100 worth of manufactured product. The dividends declared and paid by the German dyestuff factories in 1912 are in the neighborhood of 10 per cent on the annual turn-over. For the purpose of discussion, let us assume it is 25 per cent and let us assume that the man who makes this $100 worth of manufactured product makes 10 per cent or $10 profit on that. The textile maker, therefore, makes $10 where the dyestuff maker can make 25 cents, or more likely 10 cents, if he can manufacture as cheaply as can the German. The American dyestuff and chemical manufacturer is not and has never been attracted by that possible 25 cents profit. The textile maker is spending that dollar anyhow to sombody; the American dyestuff and chemical maker does not care to make the dollar's worth of commodity. It is of no consequence to him in his business; he is making a living some other way, but the textile maker says it is a matter of life and death to him to get those dyestuffs.

An obvious question at this point is that if the dyes are so vital to the textile makers and the American dye makers will not make them, why do not the textile makers invest their money in a dyestuff plant and charge up any losses that they may sustain thereby as insurance premium to insure the sale of their goods and the profit therefrom resulting, just as they make their own soap, if need be? There is no ethical nor professional reason against their so investing their money.

"Granting that the stability of our textile and allied industries demand that these materials be produced in this country, it also follows that the financial burden and risk connected with the manufacture of the dyes should fall upon them. To this responsibility I have yet to see from the dye users of this country any adequate or sufficient answer?

"If patriotism will not induce buyers of cotton goods or sellers of cotton goods to pay more for goods made in the United States than for those made elsewhere, then why should patriotism cause the chemical manufacturers of this country to go ahead deliberately with a project in which they are sure to lose money?"

Some newspapers have suggested that the situation could be remedied by altering the policy of our patent laws by introducing requirements for compulsory working.

Dr. Hesse showed that the British working clause has been ineffective.

"The transplantation of the coal-tar dye industry to the United States is not a question of patent protection; it is nothing but an economic question, a plain matter of dollars and cents; those products can be made in this country if persons will buy those products at a fair margin of profit over the cost of domestic production, and since we know in advance that the cost of production here will be above the cost of production elsewhere, plus any prevailing duty, why should we go to the costly venture of spending millions of dollars to prove the obvious?"

"As a matter of fact, the whole world's coal-tar dye consumption is about enough to make a decent-sized business for one country. Ordinarily, it is best to do the world's work where it can be done best and to transport the products from their place of manufacture to their place of consumption. If it be necessary, for other reasons, that these products should be made elsewhere under conditions economically less favorable, then those who want those products made at such economically unfavorable place should bear the burden, but that is precisely what the dye users do not want to do; they want someone else to foot the bill.

"To bring the matter up squarely before you let me recapitulate: The 10,000 chemists in the United States are engaged in pursuits which affect over 1,000,000 wage-earners, produce over $5,000,000,000 worth of manufactured products and add $1,725,000,000 of value by manufacture each year; the business in products of and for chemical industry between the United States and Germany alone in 1913 provided 5 per cent of our total foreign business and 13.8 per cent of our balance of trade for that year. Please bear in mind that I am not by any means attempting to claim all the credit for this for the chemist; all that I ask is that his claim to recognition for intelligent, active and effective collaboration in bringing about those stupendous results be not thrown aside as worthless and that he shall not be made the target of unjust criticism because in 1914 there was a shortage of about $600,000 or 7 per cent in coal-tar dyes and because cotton dropped from 15 cents to 6 cents."

New Pyrometer and Instrument Manufacturing Concern.—The Gibb Instrument Company has been formed by Mr. W. H. Gibb for the manufacture and sale of thermoelectric pyrometers, potentiometers and the pyrochronograph. The offices of the company are in the Highland Building, Pittsburgh, Pa. Mr. Gibb has been in the pyrometer business for a number of years and is well known to the trade.

The Reburning of Lime from Alkali Waste and Other Forms of Precipitated Carbonate of Lime

BY RICHARD K. MEADE

Lime is used in a large number of chemical industries, among which may be mentioned the manufacture of caustic soda, bleaching-powder, calcium carbide, sugar, wood-pulp (by the soda process), glass and in the purification of water. In a number of these industries the lime does not enter the product at all but is obtained as a waste of the process in the form of precipitated calcium carbonate and may be converted into caustic lime again by the application of heat. Mixed with this calcium carbonate, which has been precipitated from solution and consequently is in a very finely divided state, is a large quantity of water, the latter amounting to three to five times the weight of the solid material in most cases.

Among those industries in which the lime is precipitated in the form of a carbonate, may be mentioned the manufacture of caustic soda, sugar, wood-pulp and in the purification of water. The lime obtained by most plants of the latter character, however, is small and it is only where water softening operations are extensive that sufficient carbonate would be obtained to justify an attempt to reclaim this. In the other three industries mentioned, however, the quantity of lime obtained is often very large and its recovery would represent quite an inducement provided it is done in a neconomical manner.

The disposal of manufacturing waste by dumping into streams is now causing more or less friction between the manufacturers and the communities in which they operate. Consequently in addition to the financial inducement of reconverting this waste lime into lime would be the satisfaction to the manufacturer of removing a source of contention with his neighbors. Where lime waste is pumped on low ground by the manufacturer, or is carted away and dumped, this represents a direct expense which its conversion into lime would do away with.

In the manufacture of caustic soda there is carried off with the lime sludge a certain small amount ($\frac{1}{2}$—1 per cent) of caustic soda, and if this sludge is converted into lime this soda is recovered, adding to the saving to be effected by the process.

So far as I know, no attempts were ever made to burn waste lime by moulding the material into bricks and burning these in an upright kiln. The rotary kiln employed by the cement industry, however, offered a means of burning the waste lime and its use here was naturally suggested by the fact that it had been employed for burning fresh water marls which resemble alkali waste in physical properties.

The attempt to burn alkali waste in a rotary kiln began about 1900 and the kiln was first employed in connection with dryers. This installation had been already tried on wet materials in the cement industry and proved a failure. The use of dryers in recovering waste was soon abandoned and the employment of long kilns following the cement practice was substituted. This, in connection with various schemes for thickening the waste sludge so as to reduce the water to be evaporated have made the reburning of the waste lime commercially profitable.

Among those industries in which lime is being recovered at one or more plants may be mentioned the manufacture of caustic soda, sugar, wood-pulp and soap. These plants have generally proved successful. Naturally, as I have said, the early attempts to convert this sludge into lime met with some mishaps, largely owing to a lack of knowledge on the part of the experimenters as to the fundamental principles of rotary kiln operation and design, but the process has been worked out on a practical basis and where lime is being purchased at a cost of over $3 per ton it will generally prove economy to put in a lime recovery plant, provided the quantity of sludge obtained is not too small.

As received from the caustic soda plant the lime sludge usually contains a large quantity of water, as we have said. It will be practically an impossibility to burn this material in this condition economically owing to the amount of water which would have to be evaporated. If this sludge is allowed to settle for twenty-four hours it is possible to drain off much of the water and the resulting thickened sludge or slurry will contain about an equal weight of water and of carbonate of lime and may be burned with an expenditure of about 800 lbs. of coal for 1 ton of lime. Should it be desired to reduce further the quantity of water there are a number of very satisfactory mechanical filters on the market and these may be employed to do this work. The installation of a continuous drum filter, the product from which would fall directly into the kiln, would prove efficient and labor saving.

In small lime recovery plants (10 to 15 tons of quick lime per day), the item of labor will usually amount to more than that of fuel and it will prove more economical here not to thicken the sludge beyond the point where it can still be handled with a pump. It is possible to handle a mixture of 55 per cent of carbonate of lime and 45 per cent of water successfully with a centrifugal pump and the mixture of half and half can be easily handled. If it is burned in this condition the material may be pumped directly into the kiln, using a valve to control the flow and allowing the excess to circulate back into the feed tank, thus keeping the consistency uniform.

Where the plant is large, however, better results will be obtained on the score of economy if thickeners such as the Dorr and suction filters of the continuous type are installed and as much water as possible is drawn from the lime sludge. By this means the water in the sludge may be reduced to 30 per cent, which will reduce the quantity of fuel required for burning to 600 lbs. of coal per ton of lime produced.

We have seen statements to the effect that lime sludge could be burned with about 500 lbs. of coal to 1 ton of lime. This figure is entirely too low and I do not know of any concern which is burning with this amount of fuel—600 to 700 lbs. of coal per ton of lime is nearer the correct figure.

Generally producer gas is used for burning lime sludge. Where available and cheap, however, natural gas or fuel oil would be superior fuels and would reduce the labor by one man per shift. Between 9,000 and 11,000 cu. ft. of natural gas (950 B.t.u. per cu. ft.) are required to burn a ton of alkali waste or from 60 to 80 gals. of oil.

The capacity of a rotary kiln burning alkali waste will vary largely with the condition of the waste when fed to the kiln as regards its water content. If properly installed, a 6 ft. in diameter kiln 100 ft. long will burn at least 30 tons of quick lime per day when working on a waste containing 45 per cent water. An 8 ft. x 125 ft. kiln on the same material will have a capacity of at least 75 tons of lime per day.

The cost of burning lime, including interest on the investment necessary and depreciation on the plant will vary between $2 and $3 per ton, depending on the quantity of waste to be recovered and the cost of fuel.

To operate the plant there will be required per shift one man to take care of the producer, one man to attend the kiln and if mechanical filters are installed from 1 to 2 men to look after these. If the slurry is pumped directly to the kiln, the first two men only are needed and indeed in very small plants one man alone may be trained to do the work with the occasional assistance of another man to place coal in the bunkers and wheel away the ashes from the producer.

The power required by the plant will amount to about 15 kilowatt-hours per ton of lime produced. That is a plant producing 25 tons of lime per day will require about 375 kilowatt-hours per day. The repairs will amount to about 15 cents per ton of lime produced and will consist chiefly of relining the lower third of the kiln about once a year and the lining of the producer about as often. Owing to the slowness with which the kiln revolves repairs and renewals to the carriers and driving gear are infrequent. The pro-

small round nodules resembling very much a bird's egg in appearance and these are usually slightly colored from impurities in the lime. The lime drops from the kiln into a rotary cooler and is cooled by a current of air passing through the latter. This air is used for combustion and hence the lime in cooling serves to preheat the air.

The lime should be elevated from the cooler into a bin and it may be dumped from this into barrows and wheeled to the caustic soda plant or preferably the lime bin may be located in the caustic soda building and the material conveyed from the cooler to this by means of an elevator and screw conveyors.

The gas producer may be located at any convenient point, but should not be further away from the kiln than is absolutely necessary owing to radition losses. For a large kiln two 10-ft. gas producers may be necessary. In order to save labor the coal for the gas producer should be lifted by a bucket elevator into a steel bin above the producer and drawn from this bin to the latter as needed. This latter should be sufficiently large to hold twenty-four hours' run for the producer or if the plant is small at least a carload of coal.

The cost of a plant for the recovery of lime sludge will vary entirely with the size plant to be erected, fuel employed, class of construction used, etc. A small plant may be put up for about $12,000 to $15,000, which will have a capacity of about 10 tons of lime per day. A plant for 25 tons per day will cost about $17,000 to $20,000 and one for 40 tons of lime per day approximately $20,000 to $25,000. If oil or natural gas are to be used for a fuel the cost will be materially less, while the cost will be increased somewhat by the installation of continuous mechanical filters, etc.
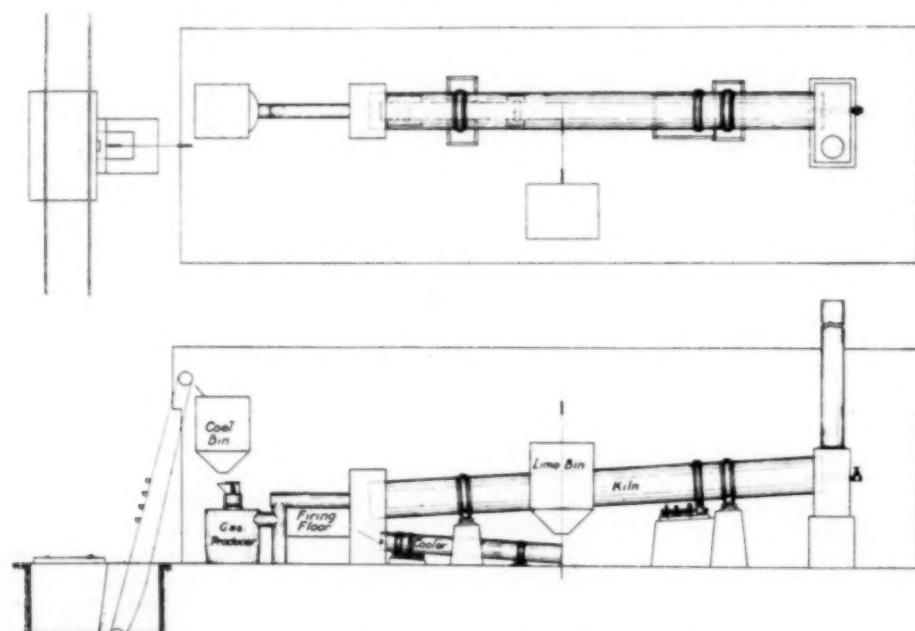
FIG. 1—PLANT FOR THE RECOVERY OF LIME FROM WASTE CARBONATE OF LIME AND LIME SLUDGE

ducer will require from 300 to 400 lbs. of steam at 60 lbs. pressure per ton of lime produced.

Fig. 1 illustrates a small plant for the burning of lime sludge, which we have designed. In this plant the percentages of water in the waste is reduced to as low a percentage as will permit of the pumping of this latter. This is done by allowing the waste to settle in two large tanks (not shown in this drawing) provided with a movable syphon tube. The contents of one tank is allowed to settle while that of the other is being fed to the kiln. The sludge is allowed to settle 24 hours when the water is drained off. The slurry is then agitated by means of compressed air to remove the more solid portion at the bottom and to make it of uniform consistency, when it is pumped into the kiln by means of a small centrifugal pump. A valve controls the flow of slurry to the kiln and this valve is opened and closed by a mechanism which may be operated from the firing end of the kiln. The excess slurry goes back into the tank and serves to keep the contents of the latter agitated. The rotary kiln is of the ordinary type and if desired Z-bars may replace the fire brick in the upper end of the kiln.

The lime is obtained from the kiln in the form of

Recovered lime consists of small, slightly oval lumps ranging in size from that of a walnut down to dust. The color is usually slightly yellowish or greenish. The lumps slake slightly slower than rock lime and consequenty causticise somewhat slower, but this is made up for by better settling of the precipitated carbonate of lime due to its coarse grain. The lime will pick up some slight impurities from the process and also from the kiln lining, so that it is not possible to burn the same lime over and over indefinitely. Instead of starting with a fresh lot of lime, therefore, it is the general practice to introduce a small quantity of fresh lime into the system at regular intervals. From 5 to 10 per cent is sufficient in most cases. The recovered lime, if burned at all skillfully, will contain fully as much caustic lime as the best lump lime made from limestone. The kiln used for recovering lime waste may also be used to burn lime from limestone provided this latter is crushed to pieces ½ in. and under.

Baltimore, Md.

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The Arizona Copper Co. produced during January 1816 tons of copper, some of which was from an accumulation of partly treated material.

Solution Control in Ferric-Chloride Leaching of Sulphide Copper Ores

BY F. N. FLYNN AND ROGER H. HATCHETT

Smelter Superintendent and Smelter Metallurgist of Arizona Copper Co., Ltd.

Determination of Iron and Copper in Chloride Solution

When chalcocite is decomposed by ferric chloride as a solvent, the resulting solution may contain ferrous and ferric iron and cuprous and cupric copper, according to equations (1) and (2) representing theoretical reactions.

$$(1)\ Cu_2S + 2FeCl_3 = 2FeCl_2 + 2CuCl + S$$
$$(2)\ Cu_2S + 4FeCl_3 = 4FeCl_2 + 2CuCl_2 + S$$
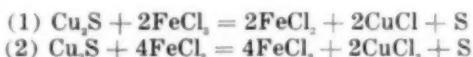
It is apparent from these equations that a comprehensive laboratory investigation of the action of ferric chloride as a leaching agent for sulphide ores of copper, and the subsequent treatment of the resulting liquor, requires that the chemist be able at any stage of the operation to determine in what condition the iron and copper salts exist in the solution.

A scheme for estimating these quantities, and that served as a guide in conducting leaching experiments, was worked out in the laboratory of the Arizona Copper Company, Ltd., Clifton, Ariz. Experiments were not carried far enough to prove that the method gives exact or quantitative results. Details of procedure are given for anyone interested in this work who has no better scheme, and who may have time and apparatus to determine the limits in which the method is trustworthy.

Total Iron

To a measured quantity of the neutral solution to be tested add a little hydrochloric acid. Boil with test lead to precipitate copper and reduce iron. Filter and titrate the iron in the filtrate with a standard solution of potassium permanganate or potassium bichromate as desired, preparing the solution accordingly. This titration gives *total iron* in the solution.

Ferrous and Ferric Iron

To a second measured portion of the cold neutral solution add an excess (2 or 3 grams) of precipitated calcium carbonate and stir vigorously for two or three minutes. Ferrous iron remains in solution, but all the ferric iron is precipitated as ferric hydroxide thus:

$$2FeCl_3 + 3CaCO_3 + 3H_2O = 2Fe(OH)_3 + 3CaCl_2 + 3CO_2$$

Filter and thoroughly wash the precipitated ferric hydroxide. The precipitate and filtrate are separately prepared for titration by reducing the hydrochloric acid solution with test lead, and the iron contents determined by the method used for total iron. The sum of the two titrations giving ferric and ferrous iron should equal the total iron previously found.

The separation of ferric and ferrous iron by precipitation with calcium carbonate and filtering must be done without heating the test. If the neutral solution is made hot, a precipitate usually appears before calcium carbonate is added. And, further, more copper is precipitated from a hot than from a cold solution. The copper thrown out increases the bulk of precipitate and makes it more difficult to filter and wash.

Total Copper

Determine total copper by any reliable method. A rapid scheme is to measure a third portion of original solution and completely oxidize it with potassium chlorate and hydrochloric acid. Neutralize with sodium carbonate, acidify with acetic acid, add two or three grams of sodium phosphate to precipitate iron. Now add three or four grams of potassium iodide and titrate with a standard solution of sodium thiosulphate as in the ordinary titration for copper. This titration gives *total copper*.

Cupric and Cuprous Copper

A fourth measurement of sample is acidified with hydrochloric acid, three or four grams of potassium iodide added, diluted, and the total oxidizing power determined by titrating the liberated iodine with a standard solution of sodium thiosulphate (1 cc = 5 mg Cu, or 4.40 mg Fe). This titration measures the ferric iron and cupric copper together. From the burette reading, subtract the equivalent of ferric iron already determined, and calculate the difference as copper, which is copper present as *cupric chloride*.

Sometimes the end point is not permanent in the thiosulphate titration for iron and copper. To check the result another sample may be measured and the total reducing power determined by titrating in a sulphuric acid solution with a standard solution of potassium permanganate (1 cc = 10 mg Fe, or 11.37 mg Cu). This titration gives cuprous copper and ferrous iron together. The equivalent of ferrous iron already found is deducted from the burette reading and the difference calculated as copper, which is the copper present as *cuprous chloride*.

Known quantities of the purest salts obtainable were weighed and mixed in solution and the results of separating the iron are given in Table I.

TABLE I

Test No.	Milligrams Weighed in Mixture				Milligrams Iron Found by Calcium Carbonate Separation	
	Fe as FeCl₃	Fe as FeCl₂	Cu as CuCl₂	Cu as CuCl	Ferric in Precipitate	Ferrous in Filtrate
1	125	...	...	...	125	...
2	...	125	...	...	...	125
3	125	125	...	...	125	125
4	125	...	125	...	125	...
5	125	...	...	80	100	25
6	125	...	...	125	80	45
7	125	125	125	...	175	75
8	125	125	...	125	110	140
9	125	125	125	125	112	138
10	...	125	125	...	25	100
11	...	125	...	125	9	116
12	...	125	125	125	14	111

Notes.—When iron salts alone are dealt with, the separation with calcium carbonate can be completed so quickly that oxidation from working in the atmosphere is inappreciable. If either cuprous or cupric salts are added to a solution of iron salts, some copper is usually precipitated with the iron, and filtration becomes retarded, apparently caused by oxychlorides of copper forming. The addition of ammonium chloride helps to make filtration quicker.

Mixtures made of known weights of chlorides of iron and copper show that cupric or cuprous chloride accelerates the oxidation of ferrous to ferric chloride, and cuprous chloride reduces ferric to ferrous chloride. The extent to which such reactions go on in solution in either direction before stable equilibrium of the system is reached is governed in some degree by the relative quantities of these substances present. This, no doubt, explains why weighed quantities of these salts were not recovered in the same condition in which they were mixed.

Arizona Copper Co.,
Clifton, Ariz.

Tropical Agriculture.—The *Proceedings of the Third International Congress of Tropical Agriculture*, held last June in London, have just been published in form of volume of over 400 pages (London: John Bale, Sons and Danielsson, 10s. net). It contains the abstracts of the more than 150 pages presented and reports of the discussions, together with the address of the president, Professor Wyndham R. Dunston.

Notes on the Reverberatory Furnace

BY FRANCIS R. PYNE

Refinery Superintendent U. S. Metals Refining Co.

The reverberatory furnace is an apparatus for smelting ores or melting and refining metals on a suitable hearth. The heat required for this operation is obtained from the combustion of fuel within the furnace proper, the fuel being in the form of oil, powered coal, or gas, the latter being generated in a regular gas producer, or by the incomplete combustion of coal in an adjacent firebox.

The area of the hearth depends upon the size and nature of the charge it is desired to handle, some furnaces carrying a deep bath of small area, others a shallow bath of large area.

The length of the furnace is limited only by the ability to obtain the desired temperature at the uptake end, the width is limited by practical difficulties in building roofs that will stay up. The height depends upon the size of the cold charge and upon having sufficient space for the combustion of the gases.

The character of the hearth, walls and roof is dependent upon the nature of the charge and the temperature desired. An acid charge requires an acid lining, a basic charge requires a basic lining. When the temperature is high very refractory material must be used; with a lower temperature we may use less refractory and consequently less expensive material.

The radiating surface of the reverberatory being large, the heat lost by radiation may reach a considerable figure. Therefore all precautions should be taken to keep this radiation loss as low as possible. A good high-grade refractory is generally a poor insulator and should be backed up by some material which is a good insulator at the temperature of the outside of the refractory. It must be borne in mind, however, that if a refractory is used at a temperature near its softening or melting point, free radiation must be permitted else the refractory will be destroyed rapidly, in some cases even water cooling may have to be resorted to, to preserve it. Many materials which are good insulators at low temperatures lose this property and become good conductors at more elevated temperatures.

The temperature attainable in a reverberatory depends upon the calorific intensity of the products of combustion. Insufficient air to burn the fuel or an insufficient mixing of air and gas keeps down the temperature regardless of the amount of fuel burned; an excess of air has the same effect by diluting the products of combustion, thus lowering the calorific intensity.

In many cases when burning coal in an adjacent firebox attempts are made to cause complete combustion in the firebox. This causes an exceedingly high temperature locally which rapidly decreases towards the flue end of the furnace. The result is an inefficient furnace and frequent burnings out of the firebox. The fire should be handled so as to produce a large volume of combustible gases which are then completely burned in the furnace by admitting the required air. The grate area is, properly speaking, not a function of the hearth area but of the volume of the furnace; a grate that will have a satisfactory area for one furnace will not give satisfaction if the roof of the same furnace is raised several feet.

It should be borne in mind that the largest part of the heating is by radiation from the hot gases and not by actual contact. In the very short space of time taken by the gases to pass through the furnace only a very small part is in actual contact with the charge while the whole volume of the flame is radiating heat to the hearth, walls and roof.

In order for a reverberatory to properly perform its functions, its hearth, walls and roof must be heated up to or above a certain critical temperature. This temperature depends entirely upon the nature of the material being treated, and unless this temperature is attained no results are forthcoming. In an ore smelting furnace a temperature of say 2100° F. is required. If the furnace is so designed or the grade of coal is such that the highest temperature attainable is but 2000° F., nothing will occur save maintaining a large body of ore at 2000° F., no matter how much fuel is burned. And as one fuel gives so many hundred degrees more temperature than another, so is the first worth much more than the second.

Where a reverberatory furnace is used for melting and refining, it performs two separate and distinct operations. During the melting down period it furnishes sufficient heat to melt the charge and to make up for the losses by radiation. During the refining period it merely takes care of the radiation losses. Now all of this heat must be supplied at a certain definite temperature, so that if a furnace has but one source of heat supply, namely, one firebox, one gas port, or one oil burner, it is readily seen that if the furnace gets just sufficient heat from this source for melting, it will receive an excess of heat when merely keeping the metal molten by making up for the radiation losses, and any decrease in the rate of combustion will cause a lowering of the temperature. This indicates the desirability of having a plurality of sources of heat supply so that the temperature may be held constant while the amount
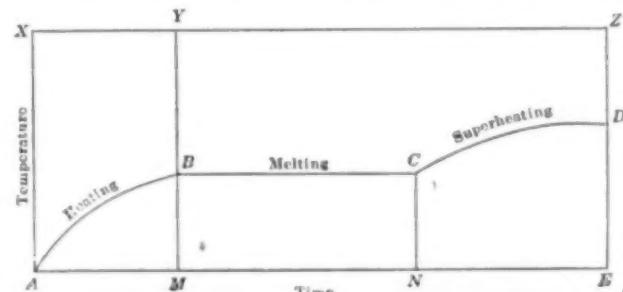
FIG. 1—THE TIME FACTOR IN REVERBERATORY SMELTING

of heat units is decreased to the desired point. This is not practicable with the coal fired furnaces, but can be applied to furnaces using oil, gas or pulverized coal.

For rapidity of melting it is necessary that the furnace be designed to produce a temperature well above the melting point of the charge. The time factor may be illustrated by Fig. 1. Let XZ represent the furnace temperature. Now a charge of metal at temperature A will be gradually heated to the melting point B in time AM, at B the latent heat of fusion BC is absorbed during the time MN, at C the superheating begins and proceeds as per the line CD in time NO.

The amount of fuel burned is proportional to AO and if this can be decreased the result will be more available melting time for the furnaces. From A to B the heat absorption is rapid under the temperature head AX, but gradually decreasing as it approaches B where the head is only BY and at the point D it is still slower, the head being reduced to DZ. Now in order to reduce the time AO we must increase the temperature head AX, requiring a more rapid combustion of fuel. The attainable temperature is limited by the nature of the fuel and the material of the furnaces, but as long as the extra fuel consumption to increase AX plus the extra furnace repairs does not exceed the saving in time and labor, the furnace will be more economical when working at the higher temperature.

Many reverberatory furnaces do not work to satisfaction because proper attention is not given to the construction of the flue end. This results in the furnace being cold at this point, while the fire end may be over-heated.

If the flue end is square as at X and Y (Fig. 2), the metal will tend to chill in these corners, due to the great radiating surface presented. By making the end tapered as AB, CD (Fig. 3), this radiating surface is lessened and the metal kept hotter. The sides AB and CD should be well backed up with a good insulator to further decrease radiation. The amount of taper depends on the available space that can be given the furnace, but in all cases it is desirable to extend it as far as practicable without unduly reducing the capacity of the furnace.

There is another reason for the reduction in volume of the flue end. As the gases pass through the furnace they drop in temperature, thereby decreasing in volume.

FIGS. 2 AND 3—CONSTRUCTION OF FLUE END OF REVERBERATORY FURNACE

If the volume of the furnace remains constant for all sections, the velocity of the gases decreases as they become cooler. Heat is being continually lost by radiation, the velocity continues to decrease and in consequence the furnace begins to build up at the flue end as the metal cools. To prevent this more fuel must be burned, causing the furnace to become overheated at the fire end and increasing the fuel cost per ton of metal. An ideal furnace would have the combustion take place gradually throughout its length, thereby keeping all parts at the same temperature, but this ideal furnace does not yet exist in practice. Therefore, in order that the velocity may be kept sufficiently high to prevent this cooling the volume of the furnace must be reduced, and this is done by tapering the sides and lowering the roof.

That part of the roof which is lowered is called the hood and besides aiding to reduce the volume of the furnace and maintaining the velocity of the gases, it throws the heat down on the metal where it tends to be coolest, and this is an important point in keeping the flue end at the proper temperature. The height above the bath of the point where the hood joins the flue is a factor which varies under different conditions. A few inches one way or the other makes a great difference in the working of the furnace and can only be determined by experiment.

The question of draft enters largely into the working of a reverberatory furnace. Unless the draft is strong enough to give proper combustion the furnace will be run very uneconomically. Sufficient draft should be furnished so that there is always a good pull on the gases passing through the furnace, otherwise the furnace will not "clear" and give a good, sharp cutting flame which is the kind needed for melting.

With coal-fired furnaces forced draft is often used, but in such cases the forced draft should be carefully regulated and never permitted to reach such a degree that there is a pressure inside the furnace. When this condition exists flame may be seen coming through any crevices in the walls and roof, the furnace will not "clear" properly and the fuel consumption is increased.

If the furnace has waste heat boilers or other devices for utilizing waste heat, sufficient draft must be allowed for to take care of the increased resistance as the tubes become dust coated, a small amount of dust on the boiler tubes and flue having a marked effect upon the passage of the gas.

Chrome, N. J.

The Extraction of Carbolic Acid from Oils of the Distillation of Coal Tar

BY WILLIAM MASON

The method, used in many works for the extraction of carbolic acid, has been to treat the oils with a solution of caustic soda; in this way a sodium phenate solution is formed and separated from the oils. This sodium phenate is then decomposed by sulphuric acid. By this method, it is easily seen, the whole of the caustic soda and sulphuric acid are lost, which materials cost, at least 8d. (16 cents) to extract 1 gal. of carbolic acid.

The cheapest and best method is to treat the light oil with caustic soda solution of about 1110 sp. gr. whereby a sodium phenate is produced which may be separated from the light oil from which it has been extracted by subsidence. This sodium phenate solution is then treated with a current of carbonic-acid gas which forms sodium carbonate, and sets the carbolic acid free. The separated carbolic acid floats on the surface of the strong sodium carbonate solution which is drawn off from below the carbolic acid, and, being causticized with lime, is employed over again continuously.

The point, however, to be considered in this method is the production and purification of the carbonic acid. This gas may be produced in a coke furnace; but much care would have to be exercised in its construction and operation, since to obtain gases containing much carbonic acid would result in a higher temperature being obtained than the materials of the furnace would with-
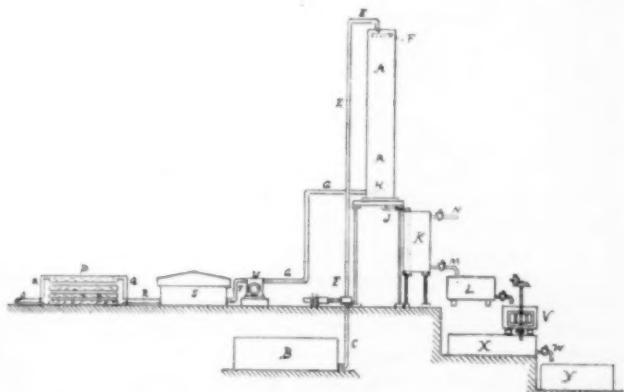
FIG. 1—THE EXTRACTION OF CARBOLIC ACID FROM OILS OF THE DISTILLATION OF COAL TAR

stand. With escaping gases containing only 6 per cent of carbonic acid, the initial temperature would be about 900 deg. C. These gases, too, would have to be purified and cooled.

Now, since tar and ammoniacal liquor are generally distilled in the same works, carbonic-acid gas may be obtained from the waste gases issuing from the sulphate of ammonia saturator. A typical gas liquor contains per 100 parts of liquor: 2.5 parts of $NH_3 = 10$ of $(NH_4)_2SO_4$; 0.5 of H_2S; 2.3 lb. of CO_2; or 10 lb. of sulphate of ammonia, 0.5 lb. H_2S; 2.3 lb. of CO_2, or 5.26 cu. ft. of H_2S and 18.7 cu. ft. of CO_2 (at 0 deg. C. and 760 mm) per 10 gal. Whence 1 ton of sulphate of ammonia would yield $5.26 \times 224 = 1180$ cu. ft. of H_2S and

18.70 $\times$ 224 would yield 4190 cu. ft. of CO_2, or a total quantity of 5370 cu. ft. of gas, and such a mixture would contain of CO_2 78 vol., and of H_2S 22 vol. per 100 vol. From these figures it is evident then, that in most works of this description there is much carbonic acid which might easily be utilized.

As the author has had practical experience with this method he will describe it by the accompanying drawing: A is a tower which is packed with stone, coke, or other similar materials, or provided with shelves of any suitable metal. B is a tank to which is supplied a solution of alkaline phenate, or cresylate obtained in the usual way. A pipe C connects the interior of the tank B to a pump D which is connected by means of a pipe E with perforations. The solution of alkaline phenate or cresylate is pumped from the tank B along the pipes C and E and escaping from the perforations formed in the pipes F flows slowly down the interior of the tower A. While flowing down the solution meets with the ascending carbonic-acid gas which is conducted to the base of the tower A by the pipe G, terminating within the base of the tower in pipe H provided with perforations through which the carbonic-acid gas escapes. The descending solution of sodium phenate or cresylate by being acted upon by the ascending carbonic acid gas is caused to become a mixture of sodium carbonate and carbolic acid. The mixed liquids on reaching the base of the tower A flow through the pipes J into a deep dividing or separating tank K, from which the sodium carbonate, as it separates from the carbolic acid, is run out by means of pipe M, fitted with a tap on the bottom of the tank, into a tank L, while the carbolic acid is run off by a pipe N, also fitted with a tap and near the top of the tank K. This carbolic acid is then made acid by sulphuric acid.

The carbonic acid used in this process is obtained from the waste gases in the manufacture of sulphate of ammonia from ammoniacal liquor which are conducted by means of a pipe O to a series of pipes P situated in a tank Q which contains water by which the pipes P are surrounded. Cold water is supplied to the tank Q in any suitable manner. By passing the waste gases formed in the manufacture of sulphate of ammonia from ammoniacal liquor through the pipes P nearly all the vapor of water and tarry matter are condensed and separated from the gases. The gases are then conducted from the pipes P by a pipe R to a purifier S which contains oxide of iron, similar to those used in the manufacture of coal gas and in this the sulphuretted hydrogen contained in the gases is extracted, and the remaining almost pure carbonic acid gas is conducted from the purifier by a pipe T to a pump U actuated in any suitable manner, by which the carbonic-acid gas is supplied through the pipe G to the perforated pipe H at the bottom of the tower A.

The above-mentioned sodium-carbonate solution is conducted into an agitator V of any suitable shape where it is causticised with lime, and after it has been so treated it is run therefrom by means of the pipe W, which is provided with a tap, into a settling tank X, in which the lime is separated. The solution is then run into the tank Y and contains from 2 to 3 per cent of caustic soda, and is of a suitable strength to treat a fresh quantity of tar oils. In this manner the process is made continuous.

This process has several advantages over the ordinary process for obtaining carbolic or cresylic acid in which sulphuric acid is employed: namely, no sulphuric is used; about 90 per cent of the caustic soda is recovered; also the liquor is utilized which in the ordinary process was difficult to dispose of, being a source of nuisance by polluting river streams and other waste courses.

Finally, there is one other matter which requires attention, and that is the condensed water from the coolers contains hydrogen sulphide in solution, which has to be dealt with before it leaves the works. In one works with which the author had experience it was allowed to run away into a sandy soil, and was thus got rid of. A much better method would be to dehydrate the gases as is done in the ammonia soda process, by placing a surface cooling coil between the still and the saturator at such an altitude that the condensed liquor could be syphoned back into the still, or the coil may be placed on the ground, and the condensed liquor collected in a closed vessel, may be pumped back into the still. In this way the gases issuing from the saturator would consist only of carbonic acid and hydrogen sulphide, and would, therefore, not require the large scrubbers and condensers usually employed for this purpose; besides, nearly the whole of the sulphur might be recovered in the purifier, and in works where carbonic acid is already being used, only inexpensive additions would be required, and the operations might be much quickened by using nearly pure carbonic acid.

Oxford, England.

The Non-Ferrous Metal Market

The trend of non-ferrous metal prices during April was distinctly upward. Copper was remarkably stronger and transactions were in fairly large quantities. Lead prices ranged higher early in the month, but fell off later owing to reduced export demand. Tin was the most erratic and fluctuated widely. Spelter continued at a high price in spite of a fairly large business.

Copper.—The market for this metal reached 16 cents on April 12, and ranged as high as 16.20@16.35. Domestic demand continued heavy, and as the statistical position is regarded as strong, prices are likely to range high.

Tin.—Since our last report the price for this metal has gone as high as 56@58 cents per pound, fluctuating widely on small transactions. Comparatively small business is being done. At last reports the market was unsteady at 55 cents.

Lead.—Exports of this metal continue to show an increase. The American Smelting & Refining Co. advanced the price to 4.20 cents, New York, on April 1, since which time it has remained at that point. St. Louis prices have been above the New York parity, owing to buying for export, but have again receded to 4.10@4.15 cents.

Spelter.—The unusual situation in this market continues, and prices are higher than a month ago. More buying has been done by domestic galvanizers. Spot metal continues to command a premium, while future deliveries are available at prices below the current quotations. About the middle of April New York spelter was quoted at 8.92½@9.67½ cents; St. St. Louis, 8.75@9.50.

Other Metals.—Aluminium has been quiet, with prices steady at 18¾@19 cents per pound. Business in antimony is quiet, owing to scarcity of supply. Prices range widely, according to brand, from 25 to 32 cents per pound. Quicksilver is unsettled. Prices have been as high as $67 per flask of 75 lb., New York, but about April 15 the metal was to be had at $62. San Francisco price was $64.50@$65.

A welding flux or compound patented by W. W. Hout, of Cortland, N. Y., contains boracic acid, iron or steel particles, furnace dross and calcined marble dust.

A Case for Copper Hydrometallurgy

Inexpensive and Efficient Treatment of Smelter Flue Dust and Carbonate Ore

BY GEORGE C. WESTBY

A small leaching plant of a Western copper smelter is an illustration of an adaptation of peculiar conditions to reduction of cost in the treatment of flue dust and incidentally of carbonate ores.

The flue dust which had been withdrawn from the flues in cleaning had weathered for a considerable period and contained much free sulphuric acid and soluble sulphates of copper and iron.

The former method of treatment had been to charge the flue dust into reverberatories and smelt it with the regular charges of calcined ore. There was a consequent cost for handling and serious loss through furnace draft and boiling due to the fine state of division of the material and the presence of sulphates, acid and moisture.

A former superintendent of the plant decided, in view of the composition of the flue dust, that a wet method of treatment might be devised that would be cheaper than charging the material to the furnaces, and he initiated the investigation of the problem.

The principal difficulty to be met consisted in the fact that the whole arrangement to be used in the treatment of the material must cost but little, since the quantity of flue dust available for treatment was limited and the current production hardly more than 5 tons per day. The other factors of the problem, such as the solubility of the copper, were all in our favor.

Results from Experimental Plant

To get a logical starting point and necessary data for estimates and design of plant, equipment having a capacity of about 1 ton in eight hours was put in operation. This plant consisted of a heap of flue dust, a few barrels filled with carbonate ore and fitted with filter bottoms, a flume 16 in. by 8 in. in cross section and 100 ft. long, a small Pachuca agitator, a settling launder and a series of barrels filled with iron. The plant was operated by means of a stream of water into which a laborer shoveled the flue dust as the water flowed through the launder. After agitation and settlement the solution passed successively through the carbonate ore and precipitation boxes.

The information gathered from a short trial of the experimental plant showed that the flue dust could be rapidly disposed of by a comparatively small plant, without material modification of the general arrangement tried on an experimental scale. The test established also the commercial feasibility of the scheme.

It was determined to be practicable, in view of the rapid sedimentation in the settling launder, to make the process continuous. This, however, would have necessitated the preparation of a much larger oxidized-ore yard, the inconvenience of night work and larger or longer precipitation boxes, all of which would not be warranted by the limiting conditions. Settling capacity would not have been difficult to secure as earthen settling ponds might be used.

Intermittent Process Adopted

An intermittent process was adopted and a plant designed to treat profitably about 25 tons of flue dust and carbonate ore per day. The design embraced about 400 ft. of 9-in. by 9-in. tarred wooden launder, about 500 ft. of 6-in. tarred paper conduit pipes, two earthen settling ponds or settling tanks, a heap of oxidized ore and 300 ft. of 3-ft. by 3-ft. precipitation boxes.

The wooden launder was to be so arranged that its upper lengths could be moved laterally toward the flue-dust piles as clearance was made by shoveling the material into the launder. The design called for the direct treatment of flue dust as drawn from the flue hoppers by placing the settlers sufficiently below the elevation of the hopper bottoms so that the contents of a hopper could be dropped into a launder and sluiced to the settlers. It was shown that in this manner a concentration of the insoluble values could be effected, the soluble salts and acid effectually removed and the concentrated residue easily sluiced where it could drain and later be easily handled.

The estimated cost of production per pound of copper from the flue dust was as follows:

	Cents per pound
Amortization	1.0
Iron for precipitation	2.0
Labor	0.5
Supervision, laboratory and repairs	0.5
Preliminary and experimental work	1.0
Freight, refining and selling	2.5
Total	7.5

The estimated cost of the plant was between $1000 and $1200.

The exigencies of practice suggested various changes of the general plan as laid out, but the only radical innovation consisted in dispensing with the shovelers and
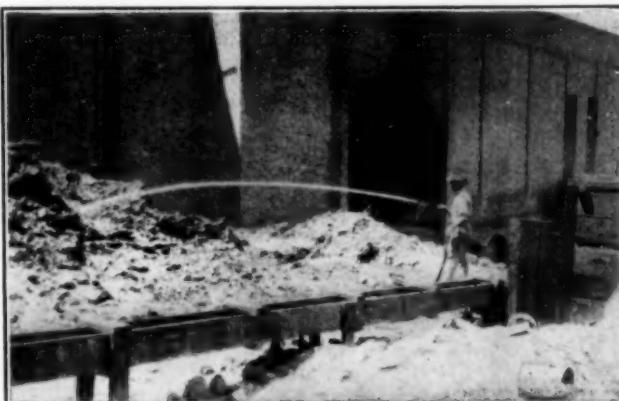
FIG. 1—SLUICING FLUE DUST

simply sluicing the flue dust from the heaps directly into the launders or conveying pipes in imitation of placer work.

Hydraulic Sluicing of Flue Dust

A stream of water from a $2\frac{1}{2}$-in. hose under 60-lb. pressure was directed through a nozzle to the flue-dust pile. The heap was rapidly disintegrated and washed into an earthen basin in which the heavier particles settled. The current carrying the flue dust then flowed through a short, broken, rocky channel to a 9-in. by 9-in. launder, the sections of which were arranged in steps in order to cause a cascading of the mixture and thorough agitation of the flue dust and water, and secondarily to break up cemented lumps of flue dust by the consequent impact. The launder was about 400 ft. long and emptied into the settlers which consisted of two Arizona tanks 28 ft. by 14 ft. by 10 ft. (substituted for the ponds first proposed). The soluble constituents of the flue dust were completely extracted before reaching the end of the launder. The Arizona tanks were usually filled in about three hours, and the sediment allowed to settle out of the solution over night.

In the morning the solution was pumped out of the tanks by means of adjustable air lifts and caused to flow into the carbonate-ore ponds. The solution was robbed of the greater part of its acid content as it gradually percolated through the ore pile to the asphalt floor beneath.

The plant was located close to a spur track, along which the carbonate-ore yard and the precipitation boxes were laid out.

Construction of Carbonate-Ore Ponds

The ore yard was formed by clearing a space of sloping ground about 80 ft. long by 70 ft. wide. The prepared ground was covered with a rough surface of broken brick, over which was spread a very argillaceous slime brought from concentrator. After drying a coat of Portland cement was brushed over the hardened clay. The yard was then completed by melting over it three coats of asphalt. The asphalting was extended almost to the top of the railroad embankment.

On this prepared floor was spread a 6-in. layer of ore, the irregular fragments of which averaged in their smallest dimension about 3 in. On this was piled about 1500 tons of ore, 9.4 per cent of which remained on a ½-in. mesh screen and 53.4 per cent passed through a ten-mesh screen. The ore was dropped over the embankment from self-dumping ore cars, distributed later by means of a steam crane and finished by a scraper to form a flat top surrounded by low walls, thus making a rough basin to retain the acid liquor charged on the ore from the settlers.

The drainage from the ore pile flowed into a small sump and this discharged into the precipitation boxes. The sump was set low enough so that any possible leak through the asphalt floor would flow along the ground through the interstices of the broken brick and finally discharge to the sump.

The carbonate ore was usually leached to a white residue in from five to six weeks. No channeling of any consequence took place, but the walls of the pile were acted on more slowly by the solutions and were usually left in place when the rest of the material was removed. A continuous percolation through the sides occurred, but this showed only in dry weather by the accumulation of crystals of cupric and ferric sulphates on the outer slopes of the walls.

On completion of the leaching and the subsequent washing, the residue was excavated by a steam crane, to the extent of its reach, and dropped on the other side of the railroad track. The remainder of the material was sluiced through gates built into the walls of the pile. The time required to clean the floor of the yard was ordinarily about twenty-four hours. To fill with fresh ore, level and prepare the top of the pile for a pond required from sixteen to twenty-four hours.

Precipitation of Copper from Solution

The strength of the solution draining from the ore pile changed slowly, but varied at different times between 0.5 per cent and 4 per cent, as the copper and acid tenor of the flue dust and wash solutions varied and the copper in the ore pile decreased. The copper in the discharged precipitated solutions remained constant at about 0.01 per cent. The discharge was controlled by leaving iron out of the precipitation launder or by increasing the quantity of iron introduced, and regulating the temperature of the solution by means of steam jets near the head boxes.

A single flume, 3 ft. by 3 ft. in cross section and 300 ft. long, was used for precipitation of copper. At intervals along the flume bulkheads were placed to maintain the solution at or near an average level of 33 in. above the bottom of the flume. The iron with which it was charged was dropped over the embankment of the railroad track from a small flatcar on which the iron had been collected from different parts of the smelter grounds.

An arrangement which saved much time by obviating the removal of the iron, consisted in the insertion of barrel staves spaced along a stringer, placed longitudinally from cross braces on the flume. A longitudinal space 7 in. wide was left along one side of the partition formed, in order to provide an opening for the shovels used in removing the precipitate. The iron was charged into the bellied side of the partition; and the precipitated copper, much of which was pulverulent, was gradually discharged through the interstices of the partition to the small compartment where it accumulated until the box was cleaned. It is obvious that this arrangement could be modified so that the precipitate could be removed from both sides of the flume; and that deflection wings, or the use of air or steam jets, or mechanical stirring would materially accelerate the precipitation of copper by inducing rapid circulation of the copper-bearing liquor through the iron.

General Results

Two men operated the plant. At set intervals during the eight-hour day they sluiced the flue dust into launders; made connections, repairs and extensions of the system; collected cement copper; supplied fresh scrap iron to the boxes where needed; and every second day

FIG. 2—SLUICING FLUE DUST

1—Tarred conduit pipe. 2—Washing flue dust out of broken brick and mortar. 3—Earthen dam.

washed and sluiced out sediment which had settled in the tanks.

The general results obtained may be fairly illustrated by data secured on one experimental batch consisting of 248 tons of flue dust and 250 tons of carbonate ore. The summary is as follows:

1	Total copper in material, pounds	19,073
2	Copper left in residue as sulphide, and soluble copper lost in sediment after washes, pounds	729
3	Copper lost in discharge from precipitation launders, pounds	200
4	Copper lost in leaks from pile, pounds	60
5	Copper lost in leaks in precipitation launders, pounds	78
6	Total copper recovered, pounds	18,006
7	Percentage recovery	94.4

Item 3 was higher than the general average loss at the discharge.

Item 4 was determined by difference, roughly checked by measurements.

Item 5 was deduced by weighing crystals scraped from the boxes and by measuring and estimating as closely as possible the tiny leaks which appeared from time to time.

Summed up the treatment described was a successful solution of a minor smelter problem, in which some of the beneficent elements of fortune were with us. Further than this, the plant lent encouragement and provided means to make experiments on the wet treatment of mill and smelter products and ores—systematic

experiments tried on a sufficiently large scale to provide really useful data applicable in future operations. Altogether the case is cited as one in which the theory and practice of copper hydrometallurgy worked together without dissention.

Ludwig, Nevada.

Industrial Motor Applications

Some Considerations Affecting the Choice of Motor and Auxiliary Equipment in the Metallurgical and Chemical Industries

BY H. B. BARNES

In undertaking the following analysis of some of the considerations entering into the broad field covered by the above title, it is not the intention of the writer to enter into the theoretical side of the problem, but rather to present in a non-technical way such information as will enable the mining or metallurgical engineer to analyze his problems; or to more intelligently review the analysis and conclusions of others as they affect his particular conditions. It is a fact that many of the technical men in charge of present day industries are men who secured their training years ago, and to whom much of the recent development of electrical machinery is unfamiliar. There is also the large class of the younger men, recent graduates of technical schools, who have not yet had an opportunity to gain through experience the familiarity with electrical equipment, and the practical considerations in connection with its use, that are necessary for its intelligent application. To such engineers it is hoped that this article may prove of interest and perhaps of value.

Choice of Systems

The average user of electric power is a consumer only, seldom a producer, and therefore the choice of the system to be used is usually made for him, as he has to use what his local power company will furnish. However, there are many cases, especially when local conditions compel the installation of an isolated plant, where the choice of the distribution system to be used must be carefully considered. Such a choice involves a study of the individual problem which can hardly be expected from one unfamiliar with the considerations involved, and it should properly be placed in the hands of a competent consulting engineer.

For reasons of efficiency, economy in transmission, etc., the use of polyphase alternating current has become well-nigh universal in this country, and practically all electric service companies supply energy in this form. The user's problem thus becomes the selection of alternating-current motors to meet his conditions, or of direct-current motors with proper characteristics, and of such transforming apparatus as may be necessary for converting the purchased energy from alternating into direct current.

In many installations made years ago, direct-current motors are still used in large numbers, but the later equipment and the equipment of nearly all new enterprises is almost invariably designed for alternating current, and for this reason the following article will deal only with alternating-current motors and their applications.

Motor Characteristics

The polyphase induction motor, either two or three-phase, has certain operating characteristics that are seldom clearly understood, either in their relation to the work to be performed or in their relation to each other, and yet it is only by a complete understanding of these characteristics that an intelligent selection can be made to meet certain predetermined conditions.

The familiar induction motor of the so-called "squirrel-cage" type is ideal in its simplicity of construction and operation due to its freedom from brushes, moving wires, and from all wearing parts except the bearings, which are usually made dust-proof and with automatic ring-oilers which require a minimum amount of attention. The construction of this apparently simple squirrel-cage rotor, as the revolving member is termed, has a vital bearing on the service to be rendered by the motor for the following reasons:

1—The starting torque of a squirrel-cage motor, for a given applied voltage is approximately inversely proportional to its rotor resistance.

2—The full-load running efficiency of the same motor is also an inverse function of its rotor resistance.

It is thus obvious that the construction required to produce maximum starting torque is the identical construction that produces the worst running characteristics, so that it becomes necessary to compromise or to eliminate these opposing tendencies. Assuming that a certain rotor resistance gives maximum running efficiency and the best regulation, approximately eight times this resistance is required to produce maximum starting torque in the same motor. This problem has given rise to several different forms of rotor construction. The familiar squirrel-cage rotor with low-resistance end rings is the standard construction for motors designed for starting under relatively light loads or where the load can be thrown on after the motor is up to speed, and this is the type of motor most generally used.

For intermittent operation where high starting torque is required and close speed regulation is not essential, such as in elevator work, the squirrel-cage motor with high-resistance rotor is frequently used on account of the simplicity of its control, and there are conditions, as for instance where long line-shafts have to be started, where slight increases are made in the rotor resistance, the purchaser being willing to sacrifice a few per cent in efficiency to obtain greater starting torque, on the score of greater simplicity and reliability in his motor equipment. This "high-resistance rotor" type of motor has been standardized by several manufacturers and under certain conditions has proved a very satisfactory machine.

For constant-speed work where high starting torque is required, several methods have been developed by different manufacturers for inserting the necessary resistance into the rotor circuits during the starting period, this resistance being short circuited or cut out when the motor is up to speed, thus giving the motor the ideal running characteristics. In every case such a motor is provided with a so-called "phase-wound" rotor, the distinction being made between the form-wound coils and polar arrangement used in this construction, and the straight bars and end rings used in the "squirrel-cage" type. One manufacturer provides a centrifugal device in the body of the rotor which automatically short circuits the rotor winding when the motor approaches full speed; another provides a hand-operated device for cutting out an internal resistance, up to certain motor sizes, while all manufacturers have standardized the so-called "slip-ring" type of motor in which the terminals of the rotor winding are brought to collector rings on the shaft, through which rings any resistance combination desired may be introduced into the rotor circuits by means of external resistors and switching devices.

The so-called "synchronous" motor, which normally operates at all times in exact synchronism with the generator supplying its energy, has a relatively limited application. It is essentially a light-load starting machine, but under certain conditions is extremely val-

uable on account of the corrective characteristics which it exercises on the line and equipment used in conjunction with it. These characteristics are of an extremely technical nature, and as they are of interest chiefly to the company supplying the power, they need hardly be considered here.

There are also several commutator-type motors, both single-phase and polyphase, which have been recently put on the market, which have operating characteristics approximating those of direct-current motors. They have not come into very general use except in the smaller sizes and have only a limited application.

Character of Service

In most commercial power applications the motor service naturally falls into one of the following classes:

1—Constant speed, light starting loads.
2—Constant speed, heavy starting loads.
3—Intermittent service.
4—Variable speed.

The choice of motors for operation in any of these classes depends not only on the service to be rendered and the operating characteristics of the motor, but also on the source of power supply. Obviously a power system having several thousand kilowatts of generating capacity behind it is better able to absorb the disturbances incident to the starting of heavy loads than one of only a few hundred. Therefore the operator of a relatively small isolated plant must consider very carefully the size and type of motors he proposes to install, while the purchaser of power from a large system has few if any such restrictions.

Here again the choice between individual motors and group-drive often influences the decision, as the ability to start loads consisting of large groups of machines may often permit substantial economies through concentration of motive power into larger units.

The operation of rolls, crushers, tube-mills, concentrators and accessory equipment as used in modern milling plants is a specific instance of group-drive practice which may justify a brief digression and more detailed analysis. The ideal arrangement is to so group the machines that operate together, that they may be driven by one motor, or at least may be simultaneously controlled. Recent practice favors individual drive for certain machines, notably tube-mills. This has been directly influenced by the developments in the design and commercial production of the "herringbone" gear which has made possible gear ratios for such work that were impractical heretofore, and have made possible the direct-geared connection of standard moderate speed motors. Individual drive is not, however, to be universally recommended as an analysis of the operating characteristics of such machines will show.

No matter what the mechanical equipment of a mill may comprise, the motor equipment must be proportioned so that it can successfully start any individual part of the plant under the most unfavorable conditions that may arise in service. As a typical case may be taken a crushing or sampling plant consisting of Blake or Dodge type of crusher, one or more sets of rolls, and auxiliaries. Such a plant should properly be driven by one motor, a conclusion that is almost obvious, as a moment's consideration of the requirements of the individual machines will show. The crusher, for instance, may require only 15 to 25 H. P. to run it, but may easily require 50 to 60 H.P. to start and accelerate it. Likewise the rolls which may ordinarily use 10 to 30 H.P., may, if slightly choked, take two or three times this amount to start. Under such conditions the ability to concentrate the motive power of the entire group upon the one refractory unit is of the greatest

advantage, and is usually to be encouraged. When the total capacity of a plant is large and is made up of a number of similar units, as in some of the large reduction plants now running, the trend towards individual drive has been very marked, but it is not to be carried to extremes.

In small plants good practice seldom allows the installation of an individual motor of a size greater than 20 per cent of the generator capacity. Thus in an installation having a generator capacity of 250 H.P. a motor larger than 50 H.P. might be expected to cause objectionable disturbances all over the system due to the heavy currents required by such a motor during starting and acceleration, particularly if the motor is of the squirrel-cage type.

A squirrel-cage motor of almost any standard make may be expected to exert a starting torque of about two and one-half times its rated full-load running torque if full line voltage is applied at the motor terminals. Under these conditions, however, it may draw from the line a momentary current from seven to nine times its normal full-load requirements. As the resulting start under such conditions is so abrupt as to be objectionable and the sudden draft of current is frequently so great as to cause disturbances elsewhere on the system, it is customary, except on motors of 5 H.P. or less, to provide a "compensator" or other starting device which reduces the voltage applied to the motor during the starting period. As the starting torque of an induction motor is proportional to the square of the applied voltage, it can be shown that with a motor having a maximum torque at full voltage of 250 per cent of its normal running torque, such a motor will exert a starting torque of 100 per cent of its rating with 63 per cent of normal voltage applied at its terminals. Under this condition the momentary starting current will be limited to from two to two and one-half times the normal full-load requirement of the motor, an amount which is seldom objectionable on any well-designed distribution system.

The starting characteristics of a motor with a "phase-wound" rotor are very different. The performance curve of a typical motor of this type shows that with full-line voltage applied at the motor terminals it will exert a torque equal to 150 per cent of its rating, with a current requirement of only 150 per cent of its normal full-load amperage. The same motor will exert a maximum torque of 200 per cent to 250 per cent of its rating with a maximum current requirement of not over two and one-half times normal. Thus it will be seen that such a motor can start its rated load with vastly less disturbance to the system than can the squirrel-cage type, and also that it can develop a maximum torque condition with hardly more current than is required by the squirrel-cage type to produce normal torque.

For constant-speed work, therefore, the user must consider the size and the nature of the load and particularly the starting conditions, and also the ability of his supply system to absorb the disturbances caused by starting loads, before he can intelligently determine the type of motor to be used for each specific installation.

Intermittent service has two general classes: (1) such as elevator service where the load factor is extremely low and where the load conditions are fairly constant, and where speed variation is not required, and (2) hoist service where the work may be fairly continuous but varying constantly both as to direction and as to loads handled. Accurate speed-control is also essential and the motor may frequently be called upon to operate at reduced speed for considerable periods.

There is also an additional class of intermittent serv-

ice covering automatically controlled pumps for mine or other service.

The "high-resistance rotor" type of squirrel-cage motor, as stated above, has obtained a wide application in elevator service on account of the extreme simplicity of its control, a simple reversing switch being all that is required. A solenoid-operated mechanical brake is usually used with it, connected in series with the motor, the initial rush of current at starting being unusually effective in securing a prompt release of the brake. This type of motor also possesses electrical braking characteristics which prevent overspeeding in lowering, which will be considered more in detail later.

For hoist service the "phase-wound rotor" with slip rings is used exclusively except in the very largest hoists, where various complex systems involving the use of heavy flywheels and other devices for equalizing the load have been found commercially practicable. The three-phase "slip-ring" motor with either hand- or master-control meets fully all the requirements of the most difficult hoisting problems and such motors up to 750 H.P. are in successful every-day operation. In the smaller sizes, say up to 150 H.P., hand-control is the rule, reversing controllers with from five to as high as fifteen speeds being standard apparatus. Such equipments make possible an accuracy of control that is not approached by any but the largest steam hoists, and there is an assurance as to results from handling such a controller that the operator of a steam throttle never gets.

Another valuable characteristic of the polyphase motor for this work is the resistance offered by the motor, when connected to the line, to any tendency to overspeed it, as mentioned above. In operating a single-drum hoist, or a double-drum when unbalanced, substantial savings can be made by lowering with the motor connected to the line; both through recovery of power by the motor acting as a generator, and also by the reduction of wear on the hoist brakes, as the motor will hold the speed constant while lowering and the brakes need be used only to do the final slowing down and stopping.

For the operation of either centrifugal or plunger pumps, especially where automatic or remote control is to be used, the slip-ring motor will be found especially valuable. Automatic control usually involves the acceleration not only of the pump and its motor, but also of a column of water under conditions where any sudden shocks might be disastrous; and under these conditions the slow and uniform acceleration possible with this type of motor is most desirable. The writer was one of the first to recommend and to install phase-wound motors for this class of service, nearly ten years ago, since which time many important installations have been similarly equipped; although it is well known that for high-speed service, where bypassing or other hand-control is possible, the squirrel-cage motor may be preferable under certain conditions.

Variable Speed

The polyphase induction motor is essentially a constant-speed machine. While certain types having phase-wound rotors may be operated at reduced speeds and give very satisfactory service under such conditions, yet their efficiency at reduced speeds and under load conditions requiring constant torque, such as air-compressor or hoist operation, is so low as to make them commercially impracticable. This is due to the fact that the energy dissipated as heat in the resistance, which must be inserted into the rotor circuits to obtain reduced speeds, represents a large part of the total energy supplied to the motor; and as the mechanical output of the motor at reduced speeds is also lowered

while the electrical input remains practically constant for a given torque, obviously the overall efficiency of the combination is low. Under certain conditions of load, as for instance mine-fan operation, where the torque required decreases with a decrease in speed, this type of motor will show a decreased power consumption at reduced speed; but it is still so inefficient that it is seldom if ever used alone for such service. In the large sizes the energy otherwise dissipated in the resistors is sometimes recovered and returned to the line through so-called "regulating sets," but as these auxiliaries are large and expensive in proportion to the economies effected they are not commercially practicable, except as before stated in the larger sizes, say 300 H.P. and above.

Single and polyphase motors of the "repulsion" type have been developed in the smaller sizes which give fair speed-control and regulation over a limited range and with good efficiency. Such a motor has a commutator and brushes, the speed variations being obtained by shifting of the brush holder, or by means of external controlling devices. Due to the construction, complex as compared with the squirrel-cage motor, they are almost invariably heavier and more expensive than the constant-speed types, so that where variable speed is required it is usually cheaper and more satisfactory to obtain it by some mechanical means.

Multi-speed motors. As distinguished from variable-speed motors there is an established type of induction motor which has two, or in some cases three fixed operating speeds at any one of which it will develop its full rated torque, although of course with output reduced in proportion to the speed. In the case of the two-speed motor these are usually full and half speed, which speed change is obtained by means of a simple double-throw switch which changes the number of poles for which the primary winding is connected. Other speed changes and ratios are obtainable in the same way, but the complication involved is so great that this method is seldom used. The two-speed motor with 2:1 ratio, however, is a regularly listed standard motor and is frequently used where half-speed and full torque is desired, as in air-compressor operation.

Other methods of speed control, by the use of two or more motors in various combinations, are possible, but these are special problems.

Converting Apparatus

Although most power requirements can be met by the direct application of alternating-current motors, there are many applications of electric power which compel the use of apparatus for converting alternating into direct current; as, for instance, electrolytic work or the operation of direct-current motors for railway or other variable-speed purposes. In such a case the choice lies usually between motor-generator sets and rotary converters, with a limited use of the mercury arc or other types of so-called "rectifiers."

The motor-generator set, as its name implies, consists of an alternating-current motor driving a direct-current generator, which may, of course, be either belted or direct coupled if both machines have approximately like speeds. Such a combination possesses infinite flexibility, as obviously the motor and the generator may each be designed for the conditions as they exist; for instance, a 10,000-volt motor may be used to drive a low-voltage direct-current generator, while a rotary converter operates with an approximately fixed ratio between the a.c. and d.c. voltages. The motor-generator set has, however, certain disadvantages, among which are larger size and first cost and lower efficiency due to the double conversion of energy from electricity into mechanical power and back again.

The rotary converter, rotary transformer, or synchronous condenser as it is variously called, may be said to consist of a synchronous motor and a direct-current generator in one and the same piece of apparatus. It has a stationary field frame and a revolving armature having a commutator on one end as in an ordinary direct-current generator, and on the other end collector-rings and brushes as in an ordinary synchronous motor of the revolving-armature type. In this machine the alternating current is introduced into the armature winding through the collector rings and is commutated or rectified into a uni-directional or direct current by the revolving commutator, thus being converted without passing through the transformations involved in the motor-generator set. For this reason the overall efficiency of the rotary converter is usually higher than that of the motor-generator set, and due to its more compact construction its cost may be kept low. It has the disadvantage, however, of involving synchronous operation which is seldom clearly understood by the average operator, and also the disadvantage of having a fixed ratio between the voltage of the alternating current supplied, and the voltage of the direct current furnished by it. This ratio approximates 1 to 0.7, with slight variations according to the method of connection used. In the case of a converter delivering 250 volts direct current it would have to be supplied with alternating current at approximately 175 volts. Obviously to furnish a low alternating voltage from a transmission system carrying say 10,000 volts would require additional static transformers for this purpose, and it is the cost of this and other auxiliary equipment that frequently results in the use of the motor-generator set in preference.

Various methods have been introduced to vary the delivered voltage of a rotary converter, the customary ones being to vary the applied a.c. voltage by means of switches or induction regulators; or the use of the so-called "booster" converter, which consists of an additional winding on the converter armature which is influenced by a second or auxiliary field winding. Either of these methods is effective over a limited commercial range, but neither approximates the flexibility of the motor-generator combination.

Starting and Protective Apparatus

Intelligent selection of motor equipment should in every case be accompanied by similar attention to the starting and protective apparatus with which motors are supplied, as too often this essential detail is neglected, with the result that the motor operation is unsatisfactory when in reality the motor itself is in no way at fault. Instances almost without number might be cited to illustrate this point, but one or two selected from personal experience will be fairly representative.

In a mine-pumping installation consisting of plunger pumps driven by slip-ring motors, float-controlled automatic starting apparatus was specified, which was to have the period of acceleration adjustable up to one minute. Through an error, "current limit" control only was furnished, which in this case brought the motors up to speed in three or four seconds. This rapid acceleration was in no way injurious to the motor but had disastrous effects elsewhere, as the water pressure resulting from the inertia of the column of water in the discharge line was so great that one valve-body and two flanged connections were burst during the enforced operation of this equipment. Upon the substitution of a starting device having a fixed time element no further trouble was experienced, as the period of acceleration was lengthened to nearly fifteen seconds and the column of water was put in motion with hardly any perceptible rise in pressure.

In another instance some delicate and complex apparatus which was ideal in its theory was installed in a sampling mill, in a location where it was impossible to entirely protect it from the omnipresent sulphide dust. The result was that within less than a week the equipment was absolutely inoperative, and it was eventually replaced with other apparatus which was both cheaper and better able to stand up under the severe service conditions imposed.

Three-phase squirrel-cage motor starters may be classed under types as "star-delta," "resistance," and "compensator;" and under methods of operation as "hand-operated," "master-control," and "automatic." Each type can, of course, be operated by any method, so it is obvious that there are abundant alternatives to choose from.

The "star-delta" starter is one of the simplest forms and takes its name from the two ways in which the motor coils can be grouped. When the phase circuits of a motor designed for delta-connected operation are connected in star, the resulting combination would require 173 per cent of normal voltage to secure normal operating conditions. As the normal available voltage is only 57 per cent of this amount, the application of this voltage to the star combination is equivalent to a 43 per cent reduction of voltage applied to the delta combination which is the normal operating combination for which the motor was designed. This potential, as was shown when discussing motor starting characteristics, is sufficient to secure satisfactory starting under certain conditions. As it offers, however, only one starting torque, which may be greater or less than is desired in any specific case, it lacks the flexibility of the other systems. It also has the disadvantage of requiring six wires between the motor and the starting switch instead of the three required by other systems.

The "resistance" method of starting consists of merely inserting an ohmic or non-inductive resistance into the primary circuit, which results in lowering the voltage applied to the motor during the starting period. This is a highly inefficient method of starting, as the line current remains very high, the difference between the line voltage and that applied at the motor terminals being absorbed by the resistance, and the energy represented by it being dissipated in the form of heat. The resistance starter has the one advantage of being cheap in the small sizes, and it has secured a limited recognition for this reason.

The "compensator" method of starting is the one most generally used with squirrel-cage motors, and is standardized in various forms by practically every motor builder. It consists of a case containing either two or three auto-transformer or compensating coils, and a switching device by which a reduced potential obtained from the transformer coils may be applied to the motor terminals during the starting period. When the motor has attained full speed a second operation of the device disconnects the transformer coils and connects the motor directly to the line. By arranging for various taps or connections to the coils the starting voltage obtained from them may be conveniently changed to suit the requirements of the individual motor with which the compensator is used.

Starters for phase-wound motors have, of course, but one type, that of varying the rotor resistance. Motors having this resistance carried inside the rotor (the so-called "internal-resistance" type) are of value chiefly for obtaining easy acceleration with a minimum amount of line disturbance, their ability to start heavy loads being limited by the ability of the resistors to dissipate the heat generated during the starting period. A 15 to 30-second period of acceleration for normal load is the rating of one of the standard motors of this type

now on the market, but if either the load or the time factor is likely to be materially exceeded the purchaser should consider the use of the slip-ring motor with external resistors and switching device or controller, as it is usually termed.

Regarding methods of control, regardless of motor types, certain considerations should always be kept in mind. The familiar types of hand-operated starters are too well known to need comment here, but the introduction of large motors has brought with it a condition that has resulted in the development of "master-control" for two reasons: (1) The necessity for means to limit the rate of acceleration, and to prevent motor abuse, and (2) the necessity for means of controlling motors, the starting equipment of which is too large for manual operation, or which may be located at a distance from the operator.

The control developed to meet the first of these was largely due to the introduction of electrical equipment into industrial fields where the operators were either unable or unwilling to use discretion in handling it. Briefly, it consists of automatic switching devices which control the motor in all its functions exactly as its designer intended; the operator in charge having no control over it except to determine when it is to start and stop, and in some cases the direction of its rotation. The operator handles only the master-controller or "master-switch," as it is sometimes called, the controller proper consisting of a panel with the necessary electrically actuated switches and automatic relays on it, which may be located near the motor, or if desired, in a more protected place. The relays referred to prevent too rapid acceleration, and this style of control equipment as a whole has resulted in a remarkable decrease in the maintenance cost of the motors, as the brains of an expert are substituted for those of the average operator who may be and often is entirely ignorant of the equipment placed in his charge.

The second reason cited is also an outcome of the same conditions, as the increasingly large size of motors now frequently installed require starting and control apparatus of a size that is entirely too large to be handled manually, and these motors are also, as a rule, placed some distance from the operator. Another condition frequently arising is the simultaneous control of two or more motors by one operator. This condition is best typified by the "multiple-unit" control developed for railway motor cars, where the motors on all the cars of a train are controlled simultaneously from one point, or as in certain manufacturing establishments where a group of motors in a department are sometimes controlled from one location.

From master-control to automatic-control is only a short step, the substitution of the automatically-operated master or pilot switch for the hand-operated being merely a detail. There are, however, two general types of automatic-control which are seldom clearly understood, viz.: current-limit control and time-element control, and a brief consideration of these may be in order.

Current-limit control, as its name implies, consists of switches and relays so designed as to limit the current passing to a certain predetermined maximum. In itself this is an excellent thing, but it can easily be seen that it involves acceleration at all times at a current rate equal to the maximum that may be required by the motor at full-load full-speed conditions, as it is obvious that unless the relays are so adjusted there may occur conditions of starting load which the motor could not accelerate with less than full-load current, and, of course, the control equipment cannot be expected to differentiate between a light and a heavy starting load condition. This state of affairs may, and usually does, result in light-load starting at an objec-

tionably rapid rate of acceleration, simply because the control equipment must of necessity be left so adjusted that it can take care of the occasional heavy-load starting conditions that may occur. Under such conditions the introduction of a time element into the control system is most desirable, as it can be made to assure an almost uniform starting performance regardless of load conditions.

Assume for instance a 50-h.p. motor driving a crusher, which, when the crusher is empty, has merely to accelerate itself and the crusher flywheels. When the crusher is more or less choked the motor will have to exert additional starting torque, depending upon the amount of choking, up to perhaps two or three times its normal full-load running torque. In such a case the starting equipment would have a time element of say forty seconds, cutting out the starting resistance in steps at fixed intervals regardless of the resulting current conditions. Under such conditions if the crusher were only slightly choked the motor would start it on say the second or third point of the control, and if the crusher were badly choked it might not start until the fourth or fifth of the six or eight steps provided. Overload protection would be required only in case it was impossible to start the crusher, and the resulting motor overloads were to continue for a considerable length of time. Under such conditions an overload circuit breaker having a time element incorporated in it should be installed, which would permit the brief overloads, such as starting peaks, to exist, but which would open instantly in case of dangerous overloads or in case of light overloads continuing for a considerable length of time. Such circuit breakers are standard commercial articles.

Protective Apparatus

In the matter of protective apparatus for alternating-current motors there is not a great deal to be said, the choice between circuit breakers and fuses being usually a matter of local conditions and personal preference. There are, however, two details which are not always given the consideration that they merit, namely, protection in case of interruption of current supply, and protection against single-phase operation in the case of polyphase motors.

The result of applying full voltage to a circuit to which one or more induction motors may be connected is, of course, equivalent to closing switches at the motors themselves. Under this condition, as stated before, the motor, unless provided with automatic starting equipment, will take from seven to nine times its normal full-load running current, which, while it may not injure the motor, will result in an extremely sudden start unless, as is usually the case, the fuse or other protective apparatus acts and disconnects the motor from the line. While the effect on the motor of such treatment may not be injurious, and while the trouble and expense of replacing the protective equipment may be bearable, yet it is easy to see that if all the motors on a system were operated in this way the enormous momentary current necessary to operate all the overload protective devices on the system under such conditions would be so great that no available generating capacity could supply it, and it would be impossible to again get full voltage on the line. For this reason every motor should be supplied with some form of device that will automatically disconnect it from the line in case of an interruption to the energy supply. The majority of motor starters for squirrel-cage motors have this function incorporated in their design, and for phase-wound motor operation there are available automatic switches or circuit breakers which have this "no voltage release" attachment.

When one phase of a polyphase motor circuit is opened while the motor is in operation the motor will continue to run without apparent distress unless heavily loaded. It will, however, have its entire load concentrated on the one phase winding left in service, and this will in most cases constitute an overload on this part of the winding which, if allowed to continue, will eventually burn out and destroy the winding. It is important, therefore, that protective apparatus should be employed which, in the event of the opening of any one phase, will entirely disconnect the motor from the line, thus preventing single-phase operation and consequent damage. Unfortunately this fact is not fully appreciated, with the result that fuses are still largely employed, which of course can, and frequently do, burn out in one phase from some momentary overload condition, leaving the motor to run single-phase until it burns out, or the fact is discovered through its refusal to start subsequently. A three-phase motor running on single-phase emits a characteristic hum or buzz which is entirely different from the sound heard under normal operation, and any engineer or operative in charge of any such motors should familiarize himself with it, as much trouble may often be avoided thereby.

While much of the foregoing may seem elementary to those well acquainted with modern motor equipment and practice, yet it has been the writer's experience that much of it is unfamiliar to many engineers skilled in other lines, and it is hoped that to some of these it may prove of interest and possibly of value.

Denver, Colo.

Melting Points of Chemical Elements and Other Standard Temperatures

The following tables are reproduced from Circular No. 35 (second edition) of the United States Bureau of Standards as they should prove exceedingly handy for use.

The values of the melting points used by the Bureau of Standards as standard temperatures for the calibration of thermometers and pyrometers are indicated in capitals. The other values have been assigned after a careful survey of all the available data.

As nearly as may be, all values, in particular the standard points, have been reduced to a common scale, the thermodynamic scale. For high temperatures, and for use with optical pyrometers, this scale is satisfied very exactly by taking $c_2 = 14,500$ in the formula for Wien's law connecting I, monochromatic luminous intensity of wave length λ, and T, absolute temperature: $\log I/I_1 = c_2\lambda \log e(1/T_1 - 1/T)$. For all purposes, except the most accurate investigations, the thermodynamic scale is identical with any of the gas scales.

At high temperatures some of the values are quite uncertain; thus, while the melting point of platinum may be considered accurately known to 5 deg. C., that of tungsten is uncertain by 100 deg. C. or more. Temperatures centigrade are rounded off, and the exact Fahrenheit equivalents are usually given.

The Arizona Copper Co. produced 1600 tons of copper during the month of February, 1915.

MELTING POINTS OF THE CHEMICAL ELEMENTS

Element	C	F	Element	C	F
Helium.........	<−271	<−456	Arsenic.........	850?	1562
Hydrogen......	−259	−434	Barium........	850	1562
Neon..........	−253?	−423	Praseodymium	940?	1724
Fluorine......	−223	−369	Germanium...	958	1756
Oxygen........	−218	−360	SILVER......	960.5	1761
Nitrogen......	−210	−346	GOLD.......	1063.0	1945.5
Argon.........	−188	−306	COPPER.....	1083.0	1981.5
Krypton.......	−169	−272	Manganese...	1260	2300
Xenon.........	−140	−220	Samarium....	1300–1400	2370–2550
Chlorine......	−101.5	−150.7			
MERCURY...	−38.9	−38.0	Beryllium		
Bromine.......	−7.3	+18.9	(Glucinum)..	1350?	2462
Caesium......	+26	79	Scandium....	?	....
Gallium.......	30	86	Silicon........	1420	2588
Rubidium.....	38	100	NICKEL......	1452	2646
Phosphorus....	44	111.2			
Potassium.....	62.3	144	Cobalt........	1480	2696
Sodium........	97.5	207.5	Yttrium........	1490	2714
Iodine.........	113.5	236.3	Chromium....	1520	2768
	S_1 112.8	235.0	IRON........	1530	2786
Sulphur........	S_{11} 119.2	246.6	PALLADIUM	1549	2820
	S_{111} 106.8	224.2	Zirconium.....	1700?	3090
Indium........	155	311	Columbium		
Lithium........	186	367	(Niobium)..	1700?	3090
Selenium.......	217–220	422–428	Thorium......	>1700 <Pt.	>3090 <Pt.
TIN...........	231.9	449.4			
Bismuth.......	271	520	Vanadium....	1720	3128
Thallium......	302	576	PLATINUM.	1755	3191
			Ytterbium....	?	....
CADMIUM..	320.9	609.6	Titanium.....	1800	3272
LEAD.......	327.4	621.3	Uranium......	<1850	<3362
ZINC.........	419.4	786.9	Rhodium.....	1950	3542
Tellurium.....	452	846	Boron.........	2200–2500?	4000–4500
ANTIMONY.	630.0	1166	Iridium........	2350?	4262
Cerium........	640	1184	Ruthenium...	2450?	4442
Magnesium...	651	1204	Molybdenum.	2500?	4500
ALUMINIUM	658.7	1217.7	Osmium......	2700?	4900
Radium........	700	1292	Tantalum.....	2850	5160
Calcium.......	810	1490	TUNGSTEN.	3000	5430
Lanthanum...	810?	1490			
Strontium.....	>Ca<Ba?	....	Carbon........	>3600 for p=1 At.	>6500 for p=1 At.
Neodymium...	840?	1544			

OTHER STANDARD TEMPERATURES

Substance	Phenomenon	C	F	Variation with pressure (pressure in mm of Hg)
OXYGEN...........	Boiling...........	−183.0	−297.4	$C° = −183.0 + 0.01256 (p−760) − 0.0000079 (p−760)^2$
CARBON DIOXIDE	Sublimation in inert liquid	−78.5	−109.3	$C° = −78.5 + 0.017 (p−760)$
SODIUM SULPHATE $Na_2SO_4 + 10H_2O$	Transformation into anhydrous salt	32.384	90.291	
WATER...........	Boiling...........	100	212	$C° = 100 + 0.03670 (p−760) − 0.00002046 (p−760)^2$
NAPHTHALENE..	......do...........	217.96	423.73	$C° = 217.96 + 0.058 (p−760)$
BENZOPHENONE	......do...........	305.9	582.6	$C° = 305.9 + 0.063 (p−760)$
SULPHUR..........	......do...........	444.6	832.3	$C° = 444.6 + 0.0908 (p−760) − 0.000047 (p−760)^2$
Ag_2Cu_2.............	Eutectic freezing..	779	1434	
SODIUM CHLORIDE	Freezing...........	801	1472	

The German Kali Syndicate production of potash in 1914 was valued at about $37,128,000. This was a decrease in comparison with 1913 when the value was $45,696,000. But for the war it is estimated that the value for 1914 would have been about $49,980,000.

The importation of chemicals, drugs and dyes into the United States has average $7,700,000 per month during the last five years. In August, 1914, the total fell to $5,622,000 and in September to $5,519,000; but in November the amount had increased to nearly $8,000,000. Imports of sodium cyanide last July amounted to 134,000 pounds. This fell to 84,000 pounds in August, but rose to 2,182,000 pounds in November.

The Formation and Decomposition of Sulphates During Roasting

BY BOYD DUDLEY, JR.

(Concluded from page 226)

II. The Effect of Reaction Velocity

The velocity of a reaction occurring between the phases of an heterogeneous system is largely dependent upon the extent and the nature of the separating surface between the reacting phases. It also depends upon other circumstances of a secondary nature, such as the diffusion capacities of the liquid or gaseous reactants, and the velocity of stirring. Furthermore, it is highly probable that at every boundary between two phases equilibrium is established at a practically infinite velocity, as compared with the rates of diffusion.[1] These principles have been tested by various investigations of reaction velocity between solid and liquid phases, and have been found to hold good. While experimental proofs are lacking, there appear no good reasons why the velocities of reactions between solid and gas phases at high temperatures should not be governed by like considerations. Assuming such to be the case and applying these principles to the question of the rate of sulphate formation and decomposition, the following conceptions may be advanced.

Assume a mixture of a metal sulphate, which decomposes directly into oxide, and the corresponding oxide to be placed in a heated space containing a definite partial pressure of sulphur trioxide. The gas film in immediate contact with the solids will at all times contain sulphur trioxide to the amount corresponding to the dissociation tension of the sulphate at the prevailing temperature.

Whether the sulphate is decomposed or the oxide is sulphatized is determined by whether the dissociation tension of the sulphate is greater than or less than the partial pressure of the sulphur trioxide in the gas outside of the contact film. The rate at which the sulphate is decomposed or the oxide sulphatized depends upon the rate at which the sulphur trioxide diffuses through the contact film from the sulphate to the gas outside the film in the former case, or upon its rate of diffusion from the gas to the surface of the oxide in the latter. In either event diffusion is the controlling factor; conditions that accelerate it will increase the reaction velocity, and conditions that retard it will retard the reaction.

The rate of diffusion in any case depends mainly upon three factors, which are, the diffusion co-efficient of the gas, which in general shows rapid increase with increasing temperature, the difference between the dissociation tension of the sulphate and the partial pressure of sulphur trioxide in the gas, and the thickness of the contact film surrounding the solids.

From these facts it appears that, other things being equal, the rate at which a sulphate will be formed or decomposed will increase with increasing temperature, with increasing difference between the dissociation tension of the sulphate and the partial pressure of sulphur trioxide in the gas phase, and with increasing rate of stirring. The effect of stirring is to reduce the thickness of the contact gas film between the solid and the gas phases. It is, of course, understood that the direction of the reaction is determined by the partial pressure of the sulphur trioxide in the gas phase as compared with the dissociation tension of the sulphate at the prevailing temperature.

While the above conceptions probably represent the main features of the question of reaction velocity under the conditions being discussed, in any attempt to apply

[1] Nernst, Theoretical Chemistry, Translation of 6th Ger. Ed., p. 584

them to the study of reactions in the roasting furnace the following facts, which have been emphasized before but which are of sufficient importance to be repeated, must be borne clearly in mind. Usually in the roasting furnace an ore bed several inches in depth is treated, and, therefore, the conditions existing in the interstices of the bed at any given point are usually quite different from those existing at the surface of the bed. Consequently it is possible to have particles of a given sulphate undergoing rapid dissociation at a point on the surface of the bed of ore, while at some depth the rate of dissociation of this compound may be insignificant. In fact, due to high sulphur trioxide concentrations in the interstices of the ore bed resulting perhaps from the decomposition of a sulphate that has a high dissociation tension at the prevailing temperature, the oxide of a metal may undergo sulphatization in the deeper portions of the bed at the same time that its sulphate is being decomposed at the top of the bed.

An interesting example of the effect of the difference between the dissociation tension of the sulphate and the partial pressure of sulphur trioxide in the furnace gas upon the rate of dissociation of a sulphate is furnished by following at constant temperature the process of the complete decomposition of a sulphate that produces first a basic sulphate and then the metal oxide. As was mentioned in a preceding paragraph, basic sulphates resulting from the decomposition of the normal compounds
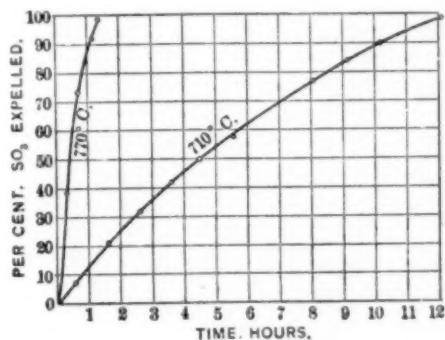
FIG. 5—VELOCITY OF DECOMPOSITION IN A CURRENT OF AIR OF Ni_2SO_4 AT 710 DEG. AND 770 DEG. C.

have in general at given temperatures lower dissociation tensions than have the sulphates from which they are produced.

Heating a thin layer of a sulphate that dissociates directly to oxide at constant temperature in a current of dry air should, in view of the arguments that have been advanced, produce a nearly constant rate of decomposition. The rate will, of course, decrease somewhat as complete decomposition is approached, due to the obstruction of the process of diffusion by the oxide produced.

On the other hand, if a sulphate that dissociates first into a basic compound is heated under similar conditions, the rate of decomposition will remain practically constant only until complete conversion of the normal sulphate into the basic compound has occurred. The basic sulphate, having at the prevailing temperature a lower dissociation tension than the normal compound, will maintain a lesser difference between the sulphur trioxide concentration of the contact film and that of the gas as a whole than did the normal sulphate. Other conditions remaining the same as before, a new and slower rate of diffusion of the sulphur trioxide from the sulphate to the gas will be established, and the rate of decomposition of the compound will be correspondingly reduced. Or rather the changed conditions will establish the rate of decomposition of the basic sulphate at a

lower figure than that of the normal sulphate. These points are nicely illustrated by two typical curves from the experiments of Hofman and Wanjukow.[9]

Fig. 5 shows the rates of decomposition of 0.3 g. of crystalline nickel sulphate at 710 deg. and at 770 deg., after the crystalline salt had been dehydrated. In this case no basic sulphates are produced, the curves being smooth and nearly straight. Fig. 6 shows the rate of decomposition of a like amount of cadmium sulphate at 960 deg. A marked change in the rate of decomposition is observed when about 80 per cent of the sulphur trioxide has been evolved, which indicates the formation of a basic sulphate containing one-fifth as much sulphur trioxide as the normal sulphate. The formula of the basic compound may, therefore, be written $5CdO \cdot SO_3$. By other and independent methods the composition of the salt was determined and found to correspond to this formula. It is evident that by following the rate of decomposition of a sulphate in the manner described it is possible, by this procedure alone, to detect the formation of basic sulphates and to establish the composition of the compounds formed.

In the discussion of the factors that regulate the velocity with which sulphates are formed or decomposed, to simplify matters, only the process of the diffusion of sulphur trioxide from the surface of the sul-


FIG. 6—VELOCITY OF DECOMPOSITION IN A CURRENT OF
DRY AIR OF CdSO$_4$ AT 960 DEG. C.

phate undergoing decomposition or to the surface of the oxide undergoing sulphatization was considered. As a matter of fact the dissociation of the sulphur trioxide plays a most important part with reference to the velocity of such reactions.

To illustrate, consider the dissociation of a metal sulphate at constant temperature and under constant conditions of air current, thickness of the layer of sulphate, etc. In most cases the temperature is such that the sulphur trioxide evolved from the sulphate tends to dissociate according to the reaction.

$$2SO_3 = 2SO_2 + O_2.$$
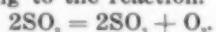
As may be seen from the equation, this dissociation is accompanied by an increase in the gas volume. Accordingly, the process of sulphur trioxide dissociation will assist diffusion in the removal of sulphur trioxide from the film in contact with the sulphate. Likewise the dissociation of sulphur trioxide within the interstices of the bed of material being treated will accelerate the removal of the compound from these spaces.

It follows that the rate of dissociation of a sulphate depends not only upon the factors affecting the diffusion rate of sulphur trioxide, but also upon the rate and the completeness of the dissociation of this compound. By accelerating the rate of dissociation of the sulphur trioxide evolved from a metal sulphate and by increasing the completeness of this dissociation the rate of dissociation of the sulphate should be correspondingly increased. The degree to which sulphur trioxide will dis-

[9] Loc. Cit.

sociate depends mainly upon the temperature, while the rate at which this compound dissociates and comes to equilibrium with its dissociation products is mainly determined by the presence or absence of efficient catalysts.

It has been already explained that contact with such substances as platinized asbestos and similar materials will greatly accelerate the reaction between the sulphur oxides and oxygen, and that certain metal oxides as ferric oxide will exert a similar influence but to a lesser degree. These facts lead naturally to the conclusion that the rate of sulphate decomposition in the roasting furnace will, other things being equal, depend to some degree upon the presence in, or absence from, the roasting ore of catalysts, ferric oxide being probably the most important material in this respect that is of common occurrence under such conditions.

The above remarks may be extended to cover the process of sulphate formation, when the conditions assumed are such as might result in the formation of a sulphate through the oxidation of sulphur dioxide and the union of the sulphur trioxide thus formed with the metal oxide. Inasmuch as this process is simply the reverse of the one that has been discussed above, it is considered unnecessary to describe it in detail.

This theory concerning the influence of admixed materials upon the rate of decomposition of sulphates has been tested by the writer in the following manner.

Aluminium sulphate (nearly anhydrous) contained in a porcelain boat was heated at constant temperature in an electric tube furnace, a current of dry air being meanwhile passed through the tube. The rate of decomposition of the sulphate was determined by removing the boat from the furnace at intervals of one-half hour and weighing. Then at the same temperature a mixture of the sulphate with ferric oxide was treated in a similar manner. As will be shown by the following detailed account of the experiments, the rate of decomposition of the sulphate was in all cases accelerated by mixing it with iron oxide. Analysis of the gases escaping from the furnace tube showed that the acceleration of the sulphate decomposition is attributable to the catalytic effect of the ferric oxide upon the dissociation of sulphur trioxide.

Aluminium sulphate was selected not because of its importance in a metallurgical sense, but because it forms no basic sulphate, and because at the temperatures involved there seemed little likelihood of complications arising due to the direct union of alumina with the ferric oxide. It was desired to show that the action of the ferric oxide in accelerating the dissociation of sulphates does not necessarily depend, as has been stated,[10] upon its union with the metal oxide to form ferrite. It may, and usually does, function simply as a catalyst. Therefore, a sulphate was chosen the oxide of which has not been observed to unite with ferric oxide at the ordinary temperatures of roasting.

Kahlbaum's crystalline aluminium sulphate (Grade I) was partly dehydrated by heating in a porcelain dish over a gas flame. The caked material from this operation was pulverized and subjected to further dehydration in the electric tube furnace. The heating was conducted at a temperature of about 350 deg. Owing to insufficient time being given to this operation the material was not completely dehydrated, the analysis showing

Al$_2$O$_3$	....	28.41 per cent
SO$_3$	....	66.50 per cent
H$_2$O	....	5.09 per cent (by difference).

The presence of this quantity of water was not detrimental, it being expelled during the first few minutes of heating at the temperatures employed in the experiments. The loss in weight during the first half-hour

period of the heating was, therefore, water and sulphur trioxide, the amount of sulphur trioxide being obtained by subtracting 5.09 per cent of the weight of sulphate taken from the total loss in weight.

The ferric oxide was prepared by first dehydrating and then calcining in a muffle furnace Kahlbaum's crystallized ferric nitrate (Grade 1). This material was not analyzed, but was tested by ignition in an open crucible, showing neither loss nor gain in weight.

The arrangement of the apparatus is shown in Fig. 7. In the preliminary experiments the exit end of the furnace tube was left open, but later, when it was desired to determine sulphur dioxide in the gas, the arrangement was as the figure shows.

In the first tests 0.5 g. of the prepared sulphate contained in a porcelain boat was heated in the furnace in a current of dry air at 800 deg. At the end of each
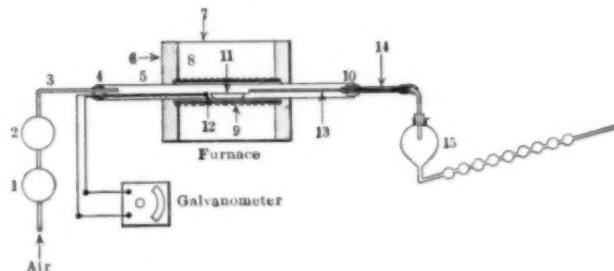

FIG. 7—DIAGRAM OF APPARATUS USED IN DETERMINING RATES OF DISSOCIATION OF $Al_2(SO_4)_3$

1—Wash bottle containing KOH solution. 2—Wash bottle containing H_2SO_4. 3—Glass tube to deliver air to furnace tube. 4—Two-hole rubber stopper. 5—Silica combustion tube, 24 in. long by 1 in. inside diameter. 6—Asbestos wood end of furnace. 7—Galvanized iron shell of furnace, 12 in. long by 9 in. diameter. 8—Magnesia for heat insulation. 9—Alundum cylinder, 10 in. long by 2 in. inside diameter; with spiral groove, 9 threads per inch on outside, to hold 16 B. & S. gauge Excello resistance wire. 10—One-hole rubber stopper. 11—Porcelain boat containing sulphate. 12—Junction of thermo couple, actual position was nearer to boat than is shown. 13—Silica tube, 1 mm. bore, for removing gaseous decomposition products rapidly from furnace. 14—Glass tube into which silica tube (13) was sealed with wax cement, for protection of silica tube. 15—Absorption tube containing standard iodine solution for the determination of SO_2.

half hour the boat was removed from the furnace and weighed. The loss in weight during the first period was sulphur trioxide and water; during the subsequent periods the losses were sulphur trioxide only. During the periods when the boat was not in the furnace, i. e., during the cooling preparatory to weighing and during weighing, the boat was handled carefully in order not to disturb or stir its contents. Owing to the fact that the depth of the sulphate powder in the boat amounted to about 2 mm., either thorough stirring between each heat or no stirring at all should be employed, if consistent results are expected. A mixture of 0.5 g. of the prepared aluminium sulphate with 0.2 g. of the prepared ferric oxide was subjected to the same treatment. The results obtained are shown in Table VIII.

TABLE VIII—LOSSES OF SULPHUR TRIOXIDE SUSTAINED BY 0.5 G. OF ALUMINIUM SULPHATE WHEN HEATED ALONE AT 800°, AND WHEN HEATED WITH FERRIC OXIDE

ALUMINIUM SULPHATE ALONE		ALUMINIUM SULPHATE+FERRIC OXIDE	
SO_3 Losses in Half-hour Periods	Cumulative Loss of SO_3	SO_3 Losses in Half-hour Periods	Cumulative Loss of SO_3
0.0210 g.	0.0210 g.	0.0309 g.	0.0309 g.
169	379	255	564
129	508	214	778
100	608	175	953

The results thus obtained indicate clearly that the rate of dissociation of the sulphate is greater when it is heated with the ferric oxide than when it is heated

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[10] Mostowitsch, Metallurgie, VIII, 771, 1911.

alone. Close microscopic examination of the mixture at the end of these heatings failed to show any indications of the formation of a compound between the ferric oxide and the other constituents of the mixture.

A second series of tests were performed wherein 0.5 g. of the prepared aluminium sulphate was heated for two and one-half hours at 735 deg. The boat was removed from the furnace at the end of each half hour and weighed. Then, after carefully but thoroughly stirring the sulphate, the boat and its contents were returned to the furnace. After heating in this manner for two and one-half hours or five half-hour periods, 0.2 g. of the ferric oxide was mixed with the material in the boat, and the mixture was subjected to further heating at the same temperature. The results are given in Table IX.

In this case it is seen that the addition of the ferric oxide practically doubled the rate of dissociation of the sulphate. The change in the velocity of decomposition after the addition of the ferric oxide is strikingly shown by plotting to scale the data of Table IX. This has been done in Fig. 8.
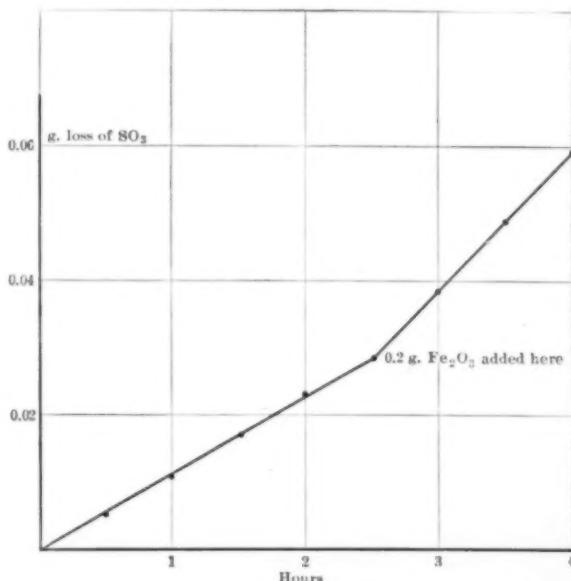
FIG. 8—RATE OF DECOMPOSITION OF $Al_2(SO_4)_3$ (0.5 G.) HEATED IN CURRENT OF DRY AIR AT 735 DEG., FIRST ALONE AND THEN WITH 0.2 G. OF Fe_2O_3

In order to establish the fact that the increase in the velocity of dissociation in the presence of ferric oxide is due to the catalytic effect of this compound upon the dissociation of the sulphur trioxide, a third series of

TABLE IX—LOSSES OF SO_3 FROM 0.5 G. OF ALUMINIUM SULPHATE HEATED ALONE AT 735° THEN MIXED WITH Fe_2O_3 AND HEATED

Losses of SO_3 in Successive Half-Hour Periods	Cumulative Loss of SO_3
0.0057 g.	0.0057 g.
56	113
55	168
58	226
55	281
102*	383
100	483
98	581

*Fe_2O_3 added previous to this heating.

tests was made, in which the ratio of sulphur trioxide to sulphur dioxide in the gas evolved from the sulphate was determined. In order for such a determination to be of value it is necessary to catch the gaseous dissociation products of the sulphate at a point near the surface of the decomposing compound, and to convey them out of the heated space as rapidly as possible. Otherwise the slow passage of the gas through the

silica furnace tube is quite likely to produce an alteration in its composition due to reaction between the sulphur oxides and oxygen.

Accordingly, in this series of experiments the air was introduced into the furnace tube as usual, but was removed, together with the gaseous dissociation products of the sulphate, through a silica tube of 1 mm. internal diameter, which was inserted into the furnace tube in the position shown in Fig. 7. From the small silica tube the gas passed through an absorption tube containing a known amount of standard iodine solution, which absorbs surphur dioxide according to the equation

$$SO_2 + I_2 + 2H_2O = H_2SO_4 + 2HI.$$

At the end of the heating period the iodine solution was washed from the absorption tube into a beaker, and the excess or unconsumed iodine was determined by titration with a standard sodium thiosulphate solution, using starch as the indicator.

In this manner the amount of sulphur dioxide in the dissociation products of the sulphate was determined. The total amount of sulphur trioxide evolved from the sulphate during the same period was given by the loss in weight sustained by the boat and its contents. The sulphur trioxide remaining undecomposed in the gas is found by calculating the amount of sulphur trioxide equivalent to the amount of sulphur dioxide found, and then subtracting this quantity from the total amount of sulphur trioxide evolved from the sulphate.

One gram of the prepared aluminium sulphate contained in a porcelain boat was heated in the tube furnace at 800°, the gas being removed and analyzed as above described. At half-hour intervals the boat was removed from the furnace and weighed. The sulphate was then stirred, and the boat was returned to the furnace. The results are given in Table X.

TABLE X—RATE OF DISSOCIATION AND ANALYSIS OF GAS EVOLVED, WHEN ALUMINIUM SULPHATE (1.0 G.) WAS HEATED IN CURRENT OF AIR AT 800°

Total Time of Heating	SO₂ Loss in 0.5 Hour	Cumulative SO₂ Loss	SO₂ Found in Gas	SO₃ Equiv. to SO₂	SO₃ in Gas	Vol. Ratio SO₃ to SO₂
0.5 hr.	0.0484 g.	0.0484 g.	0.0040 g.	0.0050 g.	0.0434 g.	8.7
1.0	435	919	32	40	395	9.9
1.5	432	1351	30	38	394	11.
2.0	466	1817	23	29	437	15.
2.5	542	2359	47	59	483	8.1
3.0	475	2834	35	44	431	9.9
3.5	415	3249	27	34	381	11.
4.0	420	3669	28	35	385	11.
4.5	415	4086	26	33	382	12.
					Average =	11.

The volume ratios of sulphur trioxide to sulphur dioxide in the last column are calculated from the weights of the gases by dividing the gas weights by the molecular weights of the respective gases. Thus,

$$\frac{\text{Volume } SO_3}{\text{Volume } SO_2} = \frac{\text{Weight } SO_3/80}{\text{Weight } SO_2/64} = \frac{\text{Weight } SO_3}{\text{Weight } SO_2} \times 0.8$$

While the ratios of sulphur trioxide to sulphur dioxide as determined during this experiment are not in close agreement, they indicate with all necessary accuracy the conditions existing within the furnace tube at a point close to the decomposing sulphate. In fact, considering the probable error of the determinations of such small amounts of sulphur dioxide, such variations in the ratio are to be expected. The average ratio of eleven volumes of sulphur trioxide to one of sulphur dioxide indicates only a slight dissociation of the sulphur trioxide. Hence the rate of dissociation of the sulphate was in this case mainly dependent upon the rate of diffusion of the sulphur trioxide from the surface of the solid.

A similar test was made at 800° under the same conditions as the preceding, only in this case 1.0 g. of the prepared aluminium sulphate was mixed with 0.2 g. of the ferric oxide. The results are given in Table XI.

TABLE XI—RATE OF DISSOCIATION AND ANALYSIS OF THE GAS EVOLVED, WHEN 1.0 G. OF ALUMINIUM SULPHATE WAS HEATED WITH 0.2 G. OF FERRIC OXIDE AT 800°

Total Time of Heating	SO₂ Loss in 0.5 Hour	Cumulative SO₂ Loss	SO₂ Found in Gas	SO₃ Equiv. to SO₂	SO₃ in Gas	Vol. Ratio SO₃ to SO₂
0.5 hr.	0.0841 g.	0.0841 g.	0.0410 g.	0.0513 g.	0.0328 g.	0.64
1.0	858	1699	379	474	384	0.81
1.5	997	2696	449	561	436	0.78
2.0	1015	3711	481	601	414	0.69
2.5	690	4401	331	414	276	0.67
3.0	620	5021	295	369	251	0.68
3.5	475	5496	226	283	192	0.68
4.0	235	5731	109	136	99	0.73
4.5	150	5881	70	88	62	0.71
					Average =	0.71

In this case, as in the preliminary experiments, the rate of dissociation of the sulphate was accelerated by the addition of ferric oxide. The average ratio of sulphur trioxide to sulphur dioxide was found to be 0.71 volumes of the former to 1 of the latter, which indicates much more complete dissociation of the sulphur trioxide than occurred when the aluminium sulphate was heated alone.

A third test was made by heating 1.0 g. of the prepared aluminium sulphate with 0.1 g. of platinized asbestos, containing about 0.025 g. of metallic platinum. The heatings were conducted for 0.5 hr. at 800° in the manner described above. The reason for trying the platinized asbestos was not on account of the possibility of any application it might have to practice, but simply to show that other catalysts will produce effects similar to that of the ferric oxide. Results are given in Table XII.

TABLE XII—RATE OF DISSOCIATION AND ANALYSIS OF THE GAS EVOLVED, WHEN 1.0 G. OF ALUMINIUM SULPHATE WAS HEATED WITH 0.1 G. OF PLATINIZED ASBESTOS AT 800°

Total Time of Heating	SO₂ Loss in 0.5 Hour	Cumulative SO₂ Loss	SO₂ Found in Gas	SO₃ Equiv. to SO₂	SO₃ in Gas	Vol. Ratio SO₃ to SO₂
0.5 hr.	0.1006 g.	0.1006 g.	0.0501 g.	0.0626 g.	0.0380 g.	0.61
1.0	940	1946	439	594	391	0.71
1.5	895	2841	384	480	415	0.86
					Average =	0.73

It will be observed that the rate of dissociation of the sulphate is accelerated by the presence of the finely divided platinum, the results from this test being practically the same as those obtained when the sulphate was mixed with ferric oxide. However, it should be noted that the amounts of platinum and of ferric oxide were by no means the same, the quantity of platinum required to produce a given effect being much less than of ferric oxide.

In order to show in graphical form the influence of the catalysts upon the dissociation rate of aluminium sulphate, the data of Tables X, XI and XII have been plotted to scale in Fig. 9.

It is interesting to compare the ratio of sulphur trioxide to sulphur dioxide found in these experiments with that to be found in the equilibrium mixture resulting from the dissociation of sulphur trioxide at atmospheric pressure. In the interstices of the layer of sulphate grains the sulphur trioxide tends to dissociate into sulphur dioxide and oxygen. Hence a comparison of the ratio of these two gases found experimentally with the theoretical ratio will indicate how nearly the conditions in the interstices approached the equilibrium conditions. From Table IV or Fig. 2 it is seen that at atmospheric pressure and 800° (the temperature of the experiments) sulphur trioxide alone will dissociate until its ratio to sulphur dioxide is only 0.433 to 1. From this it may be seen that the ratio of 11 to 1, obtained

when the aluminium sulphate was heated alone, indicates conditions far removed from the equilibrium; while the ratios 0.71 and 0.73 to 1, obtained in the presence of catalysts, indicate conditions near to the equilibrium.

Experiments along this line could be continued indefinitely, using other sulphates and other catalysts, but since the data so secured cannot be applied to roasting on a large scale in a quantitative manner, it is considered sufficient to have established the point in question. The results apparently leave little doubt as to the fact that ferric oxide and other catalysts will accelerate the rate of dissociation of sulphates by catalyzing the dissociation of the sulphur trioxide and thus removing it from the film of gas in contact with the sulphate at a greater rate than it would be removed by diffusion


FIG. 9—RATES OF DECOMPOSITION OF Al$_2$(SO$_4$)$_3$ (1.0 G.)
HEATED IN CURRENT OF DRY AIR AT 800 DEG.

a—sulphate alone; b—1 g. of sulphate with 0.2 g. of Fe$_2$O$_3$; c—1 g. of sulphate with platinized asbestos containing 0.025 g. of Pt.

alone. Ferric oxide has been considered and discussed in particular because of its very general occurrence in materials that are subjected to roasting, and because it is known to be one of the most efficient catalysts, with the exception, of course, of finely divided platinum and similar metals. However, cupric oxide is also known to be effective as a catalyst and deserves mention in this connection. Such substances as silica, alumina and probably lime are comparatively poor catalysts.

With the aid of all of the foregoing facts and conceptions it should be possible to trace what may be called the life history of a sulphate or of a number of sulphates in the roasting furnace. While, owing to the complexity of conditions and reactions within the furnace, nothing better than general statements can be made, the picture thus produced may be of some value in making clear the principles that govern the reactions.

As it is frequently conducted the process of roasting is a slow one, the cold, granular material being introduced into the furnace and having its temperature gradually raised by being advanced from the cooler to the hotter portions. In certain processes of blast roasting this procedure is not followed, and consequently this discussion does not necessarily apply to these cases. As the temperature of the ore is increased the water is expelled, and the sulphides are ignited, the ignition temperature varying with different sulphides and depending to some extent upon the grain size.

Of the sulphides commonly present in the furnace pyrite is probably ignited at as low a temperature as any. Hence at comparatively early stages of the roast the oxidation of pyrite is started, with the production of sulphur dioxide and ferric oxide or the magnetic iron oxide. In the interstices of the ore bed sulphur dioxide is produced by the partial union of the oxygen with the sulphides, and here the conditions are favorable to the production of sulphur trioxide. The temperature is comparatively low; sulphur dioxide and oxygen are mixed together in the presence of iron oxide and other catalysts; the formation of sulphur trioxide is a natural consequence of these conditions. At the low temperature prevailing the dissociation tension of ferric sulphate may be less than the partial pressure of sulphur trioxide that has been produced, and a part of the ferric oxide is sulphatized.

Then the reactions occurring in the ore bed are disturbed by the passage of a rabble, which exposes at the surface of the bed many grains that have hitherto been underneath and buries others that have been on the surface. Also the material, as a whole, is advanced toward regions of higher temperature. As a result of the stirring the ferric sulphate that has been brought to the surface, being exposed to direct contact with the furnace gas, may begin to dissociate. Similarly the iron oxide that has been formed at the surface of the ore bed, upon being buried and placed in an atmosphere comparatively rich in sulphur trioxide, may become sulphatized.

With rising temperature other sulphides are ignited, producing metal oxides and sulphur dioxide, from which the corresponding sulphates may result by processes similar to that of the formation of ferric sulphate. In these processes ferric oxide doubtless plays an important part in catalyzing the reaction by which sulphur trioxide is produced.

It has been previously noted that the dissociation tension of ferric sulphate increases more rapidly with temperature than is the case with the other sulphates. Therefore, while the ferric sulphate is readily formed during the earlier stages of the roast, the advancement of the ore to regions of higher temperature will rapidly increase the dissociation tension of this compound The sulphur trioxide tension thus maintained in the interstices of the ore bed will aid in the sulphatization of other oxides.

The action of ferric sulphate in sulphatizing other oxides by its own dissociation is, of course, not peculiar to this compound alone. Other sulphates in their turn will dissociate and assist in the formation of still other compounds of lower dissociation tension.

When mixtures of several oxides are present in the ore bed at one time, the order of sulphate formation will in general be the reverse of the order of magnitude of the dissociation tensions of the corresponding sulphates at the prevailing temperatures, i.e., the sulphate of lowest dissociation tension will form first. However, it cannot be said that the order of sulphate formation in the roasting furnace is strictly in accord with this principle, because to have sulphates formed there must first be oxides, and the ignition temperatures of the sulphides determine to some extent the temperatures at which the various oxides will appear.

An oxide that may combine with sulphur trioxide to form a basic sulphate as well as the normal sulphate will first be converted into the basic compound, which in turn may be converted into the normal compound. This is true because the basic sulphate has in general the lower dissociation tension of the two.

In considering the question of sulphate formation in the roasting furnace the important part played by catalysts, notably ferric oxide, must be remembered. These substances accelerate at low temperatures the oxidation of sulphur dioxide and thus aid in establishing relatively high concentrations of sulphur trioxide within the interstices of the ore bed. It is here, if

anywhere, that favorable sulphatizing conditions are to be found; the surface of the ore bed, being in direct contact with the furnace gases, is not a region in which the formation of sulphates is to be expected, under the ordinary conditions of roasting.

It is not to be inferred from the foregoing that there is a definite order in which the metal sulphates make their appearance in the roasting furnace and that each sulphate must be formed and then decomposed before the next of the series is produced. Nothing could be further from the truth than this idea. Sulphates may begin to form in roasting as soon as their corresponding oxides are produced, provided sulphur dioxide and oxygen are present to produce by their combination the necessary sulphur trioxide. The condition necessary for sulphate formation is that the dissociation tension of the sulphate be less than the existing partial pressure of sulphur trioxide.

This condition is most likely to occur in the deeper portions of the ore bed.

The reverse of this condition will produce the dissociation of the sulphate, and conditions tending to produce dissociation are to be expected at the upper surface of the ore bed.

Bearing in mind the fact that the ore is generally stirred to a greater or less extent, it should be evident that at no time can a single oxide monopolize all of the sulphur trioxide in any part of the furnace, and, therefore, that many sulphates may be formed and decomposed at the same time. This statement includes no consideration of the rate of formation and decomposition of the various sulphates; that is quite another matter and has been discussed at some length in a previous paragraph.

As the ore is advanced in the furnace and its temperature is increased the dissociation tensions of the various sulphates that have been formed increase, and their tendency toward dissociation increases accordingly. The rates of dissociation, when the sulphates are brought to the surface of the ore bed by rabbling, are thus accelerated; and, in addition to this, increasing temperature tends to reduce the partial pressure of sulphur trioxide maintained within the interstices of the ore bed by shifting the equilibrium of the sulphur dioxide, oxygen and sulphur trioxide system. Thus the partial pressure of sulphur trioxide in these spaces may be reduced below the dissociation tensions of many of the sulphates, and at elevated temperatures even in the deeper portions of the ore bed sulphates may undergo decomposition at a fair rate. At this stage the presence of the iron oxide and other catalysts is of great assistance in aiding the dissociation of sulphur trioxide, thus accelerating the dissociation of the sulphates. Therefore, at high temperatures ferric oxide is of assistance in the dissociation of the same sulphates that are formed by its aid at lower temperatures. Since, as has been already pointed out, the basic sulphates have in general lower dissociation tensions than their corresponding normal compounds, the former will persist at higher temperatures and for a greater time than the latter.

Finally for the complete elimination of sulphur it may in some cases be necessary to produce reactions between various gangue constituents and the remaining sulphates or basic sulphates. By this means the sulphur trioxide is liberated and such compounds as silicates and ferrites are formed, with or without complete fusion of the roasted material.

Correction: In the first part of this article, published in the April issue, on page 222, in the seventh line of the first column the word absorption should read adsorption.

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Flotation in Gold Metallurgy*

BY W. B. BLYTH

The application of flotation to the concentration of gold ores is only a question of time. Already plants have been erected in this connection, and operated (so it is said) successfully.

In the first place, being a concentration process, it is of value only where the valuable constituents of the ore are in the mineral, or when some refractory mineral is present in an otherwise free-milling ore, and it is desired to remove that mineral subsequent to cyanidation. In this latter connection the flotation process seems to have an extended field of usefulness in the preliminary concentration of cupriferous gold ores. These have been a bugbear to metallurgists for many years—not because the copper interferes with the dissolution of the gold, but because it consumes so much cyanide during the process. A very small percentage of chalcopyrite will render the treatment of a low-grade gold ore unprofitable under existing conditions. The flotation process will remove the copper in the form of a marketable concentrate, and will do it cleanly and at small cost. The remaining pulp will be in a fit state to undergo ordinary cyanide treatment.

It is doubtful if it will ever pay to float mineral from an ore that yields its gold readily in an all-sliming process. It must be remembered in this case that the mineral that is slimed in a circulating cyanide solution during crushing will yield its gold by simple, inexpensive agitation. The coarse mineral can be removed, classified, and slimed in the usual manner, and the slimed product mixed again with the rest of the pulp prior to agitation. If the mineral is floated off, then the same ultimate procedure must be adopted with the floated portion. The additional expense of flotation will be incurred, as against the cost of agitation and filtration of a large proportion of more or less barren tailing. The latter will generally be found cheaper.

When studying the features of roasting refractory floated concentrate prior to cyanidation, it must be remembered that the standard flotation process is particularly efficacious in floating mineral slime. As tables do such excellent and cheap work in separating out the coarse mineral, it may be said that, as regards gold ores, the chief field for flotation lies in the concentration of refractory slimes.

It must be borne in mind that the roasting of slimes from a cyanidation standpoint is a difficult problem, and one that, as far as the writer is aware, has never been solved. The process of drying slimes leaves lumps, and these, however small, will never roast perfectly sweet.

Filter-pressing and air-drying, followed by disintegration of the concentrate prior to roasting, might get over the difficulty. The writer, however, would emphasize that it is a problem in itself, and warns investigators that the mere fact of being able to successfully float the values from a mineralized slime does not indicate that it can be successfully treated unless there is a smelter handy to buy the concentrate.

In many cases in Western Australia the mineral constituents of the ores are so fine, and so intimately mixed with the gangue that the whole ore must be reduced to a colloidal slime before the mineral is liberated. When liberated, the mineral in this class of ore can be readily floated. Kalgoorlie ore, worth 40s. a ton, can be readily reduced to 3s., with the production of from 10 per cent to 15 per cent of concentrate, in this manner. The expense of reducing to colloidal slime, however, is very great, and this, as well as the question of the subsequent roasting prior to cyaniding of the floated slimed concentrates, is not particularly attractive.

The Cyanamid Process*

BY FRANK S. WASHBURN

The fixation of atmospheric nitrogen has had commercial application for the past ten years. During this period different types of processes have been conceived; four, the Serpek, Haber, arc and cyanamid, have seriously attempted commercial exploitation; two, the arc and cyanamid processes, have proved to be commercially practicable in the broad sense. Of these two the latter may justly claim to be of great economic importance to the world because the unit of fixed nitrogen in its first product is capable of being more cheaply produced than by any other present-known process, and because this first product has a direct and valuable use of itself and constitutes the raw material for a varied and important line of derivatives into which, for the most part, it can be cheaply transformed.

The annual productive capacity of the existing plants employing the arc and cyanamid processes is between 90,000 and 100,000 net tons of fixed nitrogen, which, at the normal average value of the product at the factory door, represents $25,000,000. This is divided in the ratio of two-thirds to cyanamid and one-third to the arc process. The American Cyanamid Company's factory at Niagara Falls, Canada, has alone a capacity in fixed nitrogen approximately half as great as the total world's installed capacity by the arc processes.

More than 3000 technical articles dealing with almost every conceivable phase of nitrogen fixation have appeared in different languages. The patents applying to the subject in all its branches number into the thousands. So far as the author of this paper knows, nothing has appeared in the nature of a differentiation of processes based on the economics of the world demand for nitrogen. It is only for a limited developmental period that the theoretical, technical advantages and limitations of related processes constitute a practical basis for hazarding opinions as to their ultimate commercial value. It is also true that until an art has had some years of commercial application it is impossible to analyze and draw sound conclusions from the economics of the situation, the final arbiter in determining the social value of any process.

The art of atmospheric nitrogen fixation is now old enough to enable one to see the economic aspects of the case, and therefore, in casting about to determine what part of this vast subject to deal with in this paper, the author thought it would be of interest and possibly of value to treat herein the broad commercial outlook for the various fixation processes, and in order to limit the matter to conditions more or less well known to all of us, conditions on the North American continent, for the most part, will be the only ones considered.

Two nitrogenous compounds, nitrate of soda and sulphate of ammonia, constitute in value 80 to 85 per cent of the total raw nitrogen compounds produced throughout the world. The value of their combined production in 1913 was between $190,000,000 and $200,000,000. It is estimated that 80 per cent went to agriculture, corresponding to an annual per capita tax on the 600,000,000 inhabitants of the earth of thirty-three cents.

Nitrogen has four main uses: as an agricultural fertilizer, as nitric acid and derivatives therefrom, as ammonia, and in dyes and various other chemical compounds. Measured in the quantity of contained nitrogen, and in view of the restricted opportunities in the United States for immediately developing the chemical

and dye industries on a large scale, we need consider as bearing decisively on atmospheric nitrogen fixation processes only the three first-mentioned uses, namely, for crop fertilizer, for nitric acid and its derivatives, and for ammonia as such.

The farmers' purchases in nitrogen used east of the Mississippi River last year approximated $75,000,000. More than 90 per cent of fertilizer nitrogen is in the form of ammonia. The normal annual consumption of nitric acid in the same region is about $7,000,000. The price paid per unit of nitrogen is about the same for each, and the percentage annual increment of consumption is about 10 per cent in each case. However, the importance of the fertilizer field in comparison with the nitric acid field, in their bearing on the fixation of atmospheric nitrogen, is not fully nor even approximately measured by this ratio of ten to one.

The use of nitric acid is along established lines looking comfortably to the future for a steady growth, with no serious limitations hampering modest development and no great unsatisfied human need demanding great development. It is essentially a small business as great industries go. The fertilizer industry has a very different significance. The population of the United States from 1900 to 1910 grew from 76,000,000 to 92,000,000, an increase of 21 per cent. Crop production increased 10 per cent in the same period. Exports of wheat and flour decreased from 31 per cent of their production to 13 per cent. The importation of foodstuffs and live animals practically doubled, while imported manufactured foodstuffs more than doubled. Beef cattle production fell off 32 per cent as the population increased 21 per cent. These figures are strikingly reflected in the increased cost of foodstuffs, which from 1896 to 1912 amounted to 80 per cent in the United States, while the general advancement in the cost of living during this period was 59 per cent in the United States, 40 per cent in England, and 40 to 45 per cent in continental Europe.

These facts point to the necessity of increasing crop yields without additional labor—and that defines fertilizer. European yields per acre cultivated are 50 to 100 per cent greater than American yields. The use of fertilizer in Europe, per acre cultivated, is enormously greater than in America. The average increase in yield in Germany for the past twenty years has been approximately 60 per cent, in the United States 20 per cent. Abroad this increase is attributed to intensive farming, better selection of seed, the rotation of crops and, to the extent of 50 to 70 per cent of the increase, to the use of commercial fertilizers.

The farmers' purchases of fertilizer in the United States last year in nitrogen and phosphorus constituents (later it will be shown why both are here included) was approximately $150,000,000. Were the cultivated lands east of the Mississippi to receive for each of two years out of every three the quantity of fertilizer normally used per acre each year in Germany, the bill would have been approximately $1,600,000,000, or ten times as great as the actual expenditure. The very limited use of fertilizers in the United States does not arise from the possibility that fertilizers do not pay. Indiana experiments, conducted in ten counties, produced an average increase of 11.6 bu. of wheat per acre, valued at $11.60, for an expenditure of $3.67. An instance of a very low return in the use of fertilizers is an unpublished record of thirty-seven experiments in Illinois in 1913, showing an average increase of 5.2 bu. of wheat, valued at double what the fertilizer cost.

The fertilizer industry to-day suffers many handicaps. These originate in part from the farmer's limited capital for properly conducting his business, his lack of knowledge which closes to him what would otherwise

be avenues of advancement and prosperity, and in part also from the fact that there is no vital, broadcast propaganda and educational bureau conducted by the fertilizer industry itself.

The greatest handicap is possibly in the material used. The industry is carried on by collecting at a great number of places throughout the agricultural regions east of the Mississippi a great variety of materials, each containing some one of the so-called plant foods, namely, nitrogen, phosphorus and potash, the last representing only about 10 per cent of the total. For the most part these materials are low in fertilizing value, and when mixed in a manner to include the low as well as the high-priced materials, there results of necessity a product of which 85 to 90 per cent is useless dead weight, only the small remainder having fertilizer value. Forty per cent of the annual fertilizer product in value is in the nitrogen constituent drawn from materials that are either by-products or wastes, such as sulphate of ammonia, slaughter-house refuse, fish scrap, vegetable refuse, waste of sugar works and distilleries, hair, leather, wool, hoofs and horns. The phosphoric acid constituent is secured from acid phosphate analyzing from 14 to 16 per cent P_2O_5, and as a general rule constituting one-half of the complete fertilizer mixture. Few of these raw materials in the broad sense are satisfactory. They are borne with because up to the present time there are no others commercially available. They pay the uttermost limit in the way of transportation charges to the point of their preparation, and after being mixed they bear a further great transportation burden to the consumer's railway station. There is a relatively large expense for mixing, storing, drying, bagging and selling. After the farmer has received his goods at the railway station, he must haul over spring roads, often almost impassable, 1,000 pounds of material in order to get 150 pounds of plant food. It is one of the recognized, recurring, contributing causes for small crops, particularly in the South, that the roads are so bad in the spring, due to rains, that farmers cannot haul the necessary amount of fertilizer.

Notwithstanding the consumer pays for nondescript materials, requiring only to be mixed in the crudest manner, a price 60 per cent greater than their spot value, the fertilizer industry as a whole, which prepares and sells the product, is conducted without measurable profit.

Unless revolutionary developments in some vital respect come to the aid of this great industry in the United States, any marked improvement is impracticable. It would appear, for reasons already set forth, that possibly the matter of greatest economic importance in the United States to-day is that conditions shall be brought about by which the farmer will use a vastly greater quantity of fertilizer than is now used. We believe the most important single contribution to this end would be a high-grade chemical salt containing nitrogen and phosphorus, well balanced and in large percentages, and possessing in a high degree the many requisites of a good fertilizer, such as being non-hygroscopic, non-toxic, finely granular in form, non-leachable in the soil and readily convertible by nature's forces into the organism of the plant. The process for the fixation of atmospheric nitrogen that will contribute the nitrogen content to such a fertilizer compound to the greatest net advantage may be justly viewed as the most important, not only to society, but also therefore to those who exploit it.

Discussions of the ultimate commercial superiority of the favorite process and the consequent complete annihilation of every other have been almost interminable. These have proceeded apart from any broad conception of time, place, the demands of mankind or the quantitative application of the product. They generally take the form of rival claims for cheapness in the cost of production, and this without much reference as to whether the unit cost applied to a form of nitrogen for which there was any particular or large demand, and without reference to whether the product was to be produced at a place and in a form enabling it to be transported to the consumer.

The Serpek process was discussed by volunteer adherents without knowledge that per unit of nitrogen fixed the necessary expenditure of heat energy from electricity alone is as great as the total electric energy consumption in cyanamid. Therefore, no suspicion was aroused that possibly nature had not placed the necessary raw material, bauxite, within practicable shipping distance of equally necessary cheap water powers. The limitations of the by-product, upon which the commercial possibilities of the process depend, were not questioned either as to the difficulties in converting it to commercial aluminum or as to the relation of its volume to the market demand for the metal.

The Haber process has been taken by the public for granted as one practicable of universal application because of its large though single use by a great concern of brilliant accomplishments in the commercial chemical world. The public does not know of the pressing problem of disposing of great quantities of sulphuric acid, and the single problem involved of how, under the local conditions, to devise the cheapest possible means of providing the requisite ammonia for using the acid in sulphate of ammonia. The electric energy necessary to the process is generally considered negligible, and yet a proposal to establish a plant close to New York involved, at the necessary power cost in that vicinity, as great an expense for electric power as the total power cost for cyanamid in an available site then under consideration for that process.

Air nitrogen fixation processes divide themselves into two broad classes, namely, those that come in at the nitric acid end, and those that come in at the other extreme, the ammonia end. There is no expectation that the various "arc" processes producing nitric acid will ever have employment in the production of ammonia compounds, for the sufficient reason that there is no prospect of ever being able to commercially convert nitric acid to ammonia. Therefore, the best that can be said of the "arc" processes is that they may be able by reason of having nitric acid as their first product, to occupy exclusively the field for the production of nitric acid. We have already seen that this field is not only relatively but absolutely a limited one for the present, as it is prospectively for the future.

The "ammonia" processes are not ready to admit, however, that there is an insurmountable barrier separating them from the nitric acid field. A tried, thoroughly workable, commercial plant for the oxidation of ammonia into nitric acid is not yet complete and in entirely satisfactory operation, but, on the other hand, the various steps necessary to the operation of such a plant have been separately brought to such stages of development as to leave no doubt in the minds of the experienced men who have worked upon the problem of the ultimate complete commercial practicability of carrying the ammonia processes for the fixation of atmospheric nitrogen through to the nitric acid producing stage.

A powerful factor operating as a disadvantage in the "arc" processes to the manufacture of nitric acid is the extraordinary difficulty of transporting the acid from the remote, cheaply developed water powers, very limited in number, where alone these processes can be employed, to the place of use for the acid, both sea and rail transportation being practically invariably

necessary. This audience does not need to be told how serious a matter is this. The nitrate compounds made from acid produced by the "arc" processes have found no place as a fertilizer in this country. Nitrate of lime, even in the so-called basic form, is too strongly hygroscopic to permit its use alone or as part of a mixture to be used through the ordinary drills by which fertilizer is distributed to the soil in this country. Even if the physical form were entirely satisfactory, it could not satisfactorily have a very large place in fertilizer mixtures in this country because of its being too readily available in the soil and because the valuable form of fertilizer nitrogen is as ammonia and not as nitrate. We have seen furthermore that the fertilizer industry demands something more than a new nitrogenous material, however meritorious it may be, merely as an additional one to the many which now constitute a part of a complete fertilizer mixture.

For a time it was thought that the treatment of phosphate rock by nitric acid might possibly find a large place in the fertilizer world. Two decisively unfavorable and irremedial results have developed from this attempt; first, the product is excessively hygroscopic, the surface when exposed taking up sufficient moisture to reduce the external parts to a molasses-like condition, and second, the content in plant food, approximately 11 per cent nitrogen and 14 per cent phosphoric acid, is markedly lower than that readily securable in the new commercial ammonium phosphate compounds resulting from the combining of ammonia and phosphoric acid. When carried to the monocalcic stage, thereby giving it the desired water solubility, the excess acid is of necessity so great that the crop is burned and destroyed. Much money has been spent on these efforts, which have always resulted in failure.

This brings us now to the consideration of the practicability of an ammonia phosphoric acid compound for agricultural use. The mono-ammonium phosphate, containing theoretically 14.6 per cent of ammonia and 61.3 per cent of phosphoric acid (P_2O_5) and the di-ammonium phosphate, containing theoretically 21.8 per cent of ammonia and 53.4 per cent of phosphoric acid, have been recognized by the scientific world for many years as fertilizers of extraordinary value, being in effect perfect materials, as they possess every qualification of a good fertilizer. The manufactured product made in this country has not developed any limitation. Under some circumstances, at least, the results in crop increase are greater per unit of ammonia and phosphoric acid than is securable from any other fertilizer or fertilizer compound, and the question has arisen whether this salt may not produce its result partially from the exercise of the same natural laws that apply to the action of manganese sulphate, for instance, in which there is a crop increase that cannot be attributed to the taking up by the plant of anything contained in the fertilizer. The effect may some day be safely attributed to the inducement that the salt has given to increased activity of the chlorophyl and thereby increased power of assimilation on the part of the plant.

The commercial ammonium phosphate product may be readily produced at will with varying proportions of ammonia and phosphoric acid, ranging from 13 and 47 to 21 and 46 per cent respectively. Thus it is that the plant food constituents of this single material, varying between 60 and 67 per cent, occupy the entire range of the usually desired relationship between ammonia and phosphoric acid. The phosphoric acid content of the commercial acid phosphate now used in agriculture, a product which, roughly speaking, results from pouring a ton of 52 deg. sulphuric acid on a ton of rock containing 30 to 32 per cent P_2O_5, contains about 14 to 16 per cent P_2O_5. In value it constitutes about one-half the

farmer's fertilizer bill in the United States each year. Whatever advantages a new kind of phosphoric-acid-containing material may have, it should be capable of being produced at a cost no greater than the per cent unit cost of phosphoric acid in acid phosphate.

Two methods of manufacturing ammonium phosphate compounds have been developed. One of these is in the proved commercial stage and can produce as cheaply, at least, as by acid phosphate. The other is in the advanced developmental stage and promises still cheaper production costs. The first is applicable wherever cheap sulphuric acid may be had, and the second, which employs the electric furnace in driving off phosphorus from the phosphate rock, is applicable only where there is cheap water power available.

When the problem is referred to the actual conditions existing on the North American continent, the most available process known for providing agriculture in a broad way with the ammonia constituent of an ammonium phosphate compound is the "cyanamid" process. Searching investigation and analysis, for four years, of prospective cyanamid manufacturing sites, covering the United States and Canada, has developed a state of facts establishing the practicability of placing ammonia at the disposal of agriculture and the arts in practically every place of large use in the United States, and cheaper and simpler than could be accomplished in any other way. This may be done by shipment of cyanamid from a central point of manufacture to these various localities and its conversion there into ammonia.

These natural tendencies toward the "cyanamid" process as the principal source for nitrogen supply might be turned aside, however, unless that material and its important derivatives, notably ammonia, could be produced and delivered to the consumer cheaper than by other means and through the employment of capital in such a manner as would induce the investment of money in the undertaking. This brings us then to a consideration of the costs of production applied to a distinctive set of conditions which correspond not only with all the important conditions surrounding the demand for and use of the product but also those which characterize an actual place of production and its geographical relation to the consumer.

There is properly a hesitancy on the part of any business enterprise to disclose actual costs. Such information is frequently made wrong use of, and the risk involved in making it public is wholly out of proportion to the gain. At the same time the author realizes that without volunteering exact statements of comparative cost figures, open to confirmation or refutation, as the case may be, it is difficult to carry conviction to the hearer that one's conclusions are sound. The founders of the American Cyanamid Company have not from the beginning been wedded to any particular process for the fixation of atmospheric nitrogen. The aim and policy have been to conduct the company's activities and research work toward the end of developing a great nitrogen industry. It has investigated many processes with the conviction that it could not hope to have permanent and ultimate success except through the application of the best. Its research work in entirely new fields, and in the regular manufacture of its product, has been practically continuous from the day it first began commercial operations in 1910. It is therefore natural that those connected with the company should feel confident of their judgment on many matters bearing upon the relative merits and limitations of various nitrogen fixation processes.

Therefore, while it may be impolitic to disclose actually attained minimum costs it may be possible to establish particular facts and comparisons which will by

their logic carry conviction as to the order of compared processes so far as production costs are concerned, without, however, expressing the exact differences in costs. For instance, by the "arc" process the factory cost of nitrogen in commercial nitric acid, excluding all power costs (derived by applying actual working records to a particular manufacturing site where all conditions are of the most favorable nature) is greater than the total cost of nitrogen in "cyanamid," including power at $10 per continuous horsepower per annum (at a site where raw materials and labor are relatively high). Furthermore, taking that particular "arc" process which is the lowest in power consumption, the power cost alone, at eight to ten dollars per continuous horsepower per annum in weak nitric acid is greater than the total cost of "cyanamid," including power at the same cost per horsepower per annum (and at a site where raw materials and labor are high). These are actual comparisons and lead conclusively to some irrefutable deductions: first, that the "cyanamid" process can fix nitrogen cheaper than the cheapest of the "arc" processes, even although a charge of ten dollars per continuous horsepower per annum is made against "cyanamid" and the power is given free to the "arc" process; second, if the cheapest of the "arc" processes, so far as power consumption is concerned, is charged only with power at the rate of eight to ten dollars per continuous horsepower per annum and the process is presented without cost or charge of any sort with all labor, raw materials and supplies, its unit of nitrogen would cost more than the total cost of the unit of nitrogen by the "cyanamid" process. It also follows from these conditions that the total cost of the unit of nitrogen in commercial nitric acid made by the "arc" process cannot by any chance be less than double the total cost of the unit of nitrogen in cyanamid made by the "cyanamid" process. We have seen that the really great application of nitrogen is at the ammonia end and these comparisons are impressive in showing not only that there is no hope of the "arc" process working into ammonia production but also, and what is of more importance, that the "cyanamid" process has to its credit a wide margin of saving in cost to span the gulf between "cyanamid" and nitric acid.

The first step in the derivation of nitric acid from cyanamid is to convert the latter into dry ammonia gas. Such conversion is now conducted in so many places and on so large a scale that the actual cost of the operation, including all losses, is no longer a matter of speculation or approximation. The efficiency has been raised in actual practice to over 99 per cent and the cost, while not negligible, is so low as to add only a small percentage to the ordinary cost of the unit of nitrogen in "cyanamid." Therefore, the facts just set forth as to the cost of the unit of nitrogen in "arc" process nitric acid, compared with the cost of the unit of nitrogen in cyanamid, apply as well to the cost of the unit of nitrogen in pure ammonia gas. Roughly speaking, therefore, there is to the credit of the ammonia, available for oxidizing it to weak nitric acid, fully one-half the cost of weak nitric acid derived by the "arc" process. As a matter of fact the indications are that this span will be bridged by the absorption of not more than one-half this difference, making weak nitric acid by the "cyanamid" process cost approximately three-quarters of the "arc" process. As power is brought below ten dollars per continuous horse-power per annum, production costs by the "arc" processes approach more nearly to costs by the "cyanamid" process. It is possible to make the general statement that the costs per unit of nitrogen in weak nitric acid may be taken as the same for both processes where power costs about $4 per continuous horse-power year.

Comparison of the costs of ammonia gas by the "cyanamid" process and the "Haber" process show, broadly speaking, that the Haber process in its most favorable environment involves a cost nearly double that of the "cyanamid" process under favorable conditions practicable of attainment.

It must not be understood that the "cyanamid" process has exhausted the possibilities of further economies in manufacture. As examples, in one new factory study in which the requisite coke is to be made by local by-product ovens, the operations so balance that the fuel gas derived is the quantity required, and as the tar and ammonia products pay for the coking, the coke is had at the price of coal. Where ammonia is derived at the cyanamid factory the sludge from the autoclaves composed of calcium carbonate and carbon may be turned back through the carbid furnaces and maintained in the cycle practically indefinitely as a carrier of nitrogen.

However, the whole story is not involved in a study of production costs, for there are other factors which may have a deciding voice, and of these we may mention as important the amount of the necessary investment for a given output, the salvage in the case of ultimate abandonment, the ratio of interest charge to the out-of-pocket expense, bearing in mind that the latter may be very much reduced by improved operating means while the former is fixed for all time. Taking the necessary investment in the "arc" process per unit of nitrogen in weak nitric acid as a basis, and assuming power to be placed upon the switchboard at an investment cost of $50 to $75 per horse-power, the corresponding investment in the "cyanamid" process for a unit of nitrogen in weak nitric acid would be about one-half, and as cyanamid or ammonia gas about one-third. It is believed that the Haber process in the United States on the same basis would involve an investment of about two-thirds to three-fourths of the "arc" process. In the contemplation of any enterprise requiring large fixed capital there is a reasonable amount of capital beyond which objections to an increased amount are not to be measured by applying the interest and amortization rate to the estimated costs of production. Converting a vast amount of gold in the bank into bricks and mortar, special machinery and appurtenances, particularly in the application of a new and special art is a serious risk for which there is no exact measure, but which in contemplating the risk should weigh heavily as a guide to judgment.

In the case of ammonia production by the "cyanamid" process the fixed investment may be as low as one and one-half times the annual value of the product and in the case of the Haber process three times. In the case of nitric acid by the "cyanamid" process the investment may be as low as one and one-fourth times the annual value of the product and in the case of the "arc" process with a power investment of $75 per continuous horse-power the fixed investment would be between three and four times the market value of the annual product.

The majority of manufacturing concerns in the United States vary in fixed investment from one to one and one-half times the value of the annual product and the inherent risk in industrial enterprises, for reasonably assured profits demand, for the most part, very special conditions where this proportion is exceeded. Even that class of investments considered most stable as to reliability, permanency and growth, namely, public utility corporations, do not exceed $4 to $6 investment per dollar gross revenue. We are therefore met in the case of the Haber and arc processes with the necessity for making an investment which, in the judgment and practice of the industrial world, is wholly out

of proportion to the market value of the annual product, while in the case of cyanamid the requirements are within the limits of ordinary commercial practice.

These considerations serve to emphasize the difficulties in commercially advancing any new enterprise. The younger technical men do not encounter these difficulties and therefore do not give them due weight. There is extraordinary difficulty, particularly in the United States, in financing a new chemical enterprise, particularly if it involves a large preliminary expenditure in research and developmental work. The banker's attitude, and properly so, is to compare assets and liabilities. Buildings, equipment and manufacturing sites are acceptable assets notwithstanding that in many companies if the business itself were abandoned there would be little or no value in the physical properties. Knowledge, processes, and ideas are not impressive assets. They are considered in large part to have been something secured at great cost, but, even with good patent protection, practically available for the use of prospective competitors without cost to them. In some other countries such enterprises are viewed quite differently, notably in Germany, where ideas are the foundation of great and profitable enterprises and where by law and practice they are better protected for the exclusive use of those who have developed them than in this country.

The promise, or even the assurance of reasonable profit, is seldom a sufficient inducement to the investor to undertake a pioneer enterprise. The competitive element which dominates almost every other activity is lost sight of by the amateur promoter. He forgets that to the mind of the prospective investor he is in the sharpest kind of competition with those presenting other types and kinds of enterprises demanding capital. His project must grip the imagination with peculiar attractiveness as well as impress the practical sense of those to whom it is brought as not only being prospectively profitable but also assuredly safe with a minimum prospect of loss and a maximum prospect of profit. Of the many subordinate advantages there may be specifically mentioned an early dividend paying period, a ready market for the securities, their acceptance as good collateral, and a ground-floor prospect in future extensions. In the end it must outweigh, in some cases, literally scores of other projects all claiming equal if not superior merit in every particular. There is another consideration of kindred merit which will be impressive if one considers that in a thing so extensively engaged in as trade in securities, one of the very largest activities in which mankind interests itself, there must grow up inevitably certain more or less arbitrary rules, practices and points of view. These all turn naturally upon the usual thing, and the usual thing is the established industry, or at least an enterprise engaged in an established industry. Therefore, the new thing has a slow and difficult road to travel and its difficulties are more than in direct proportion to the amount of capital demanded. Those fixation processes which employ and own their own water powers make a plea to capital that others cannot make, for the reason that it can generally be shown that should unexpected competitive developments in the remote future drive the undertaking to an unreasonably low return upon the investment, the rental value of the water powers for other purposes will probably insure the continuance of a satisfactory return upon the total investment.

Even if it were granted that the "cyanamid" process is prospectively to play the leading rôle in the fixation of atmospheric nitrogen so far as the most important use of nitrogen is concerned, namely, in agricultural fertilizers, and even if it were further granted that it is the logical source of nitric acid, the question may still be an important one as to whether the raw product of this process may be looked to as the source of a long and important line of nitrogen derivatives. The fact is that there is an almost interminable line of derivatives which can be produced from cyanamid with the greatest technical success and assurance and their manufacture has proved to be in some cases commercially feasible. The direct and valuable application of the raw product, cyanamid, is unique in air nitrogen fixation processes. The proof of this value lies in the fact that fully 80 per cent of the entire annual product of normally $15,000,000 value is sold as the raw product.

The principal derivative at the present time is ammonia, which has earlier herein been referred to. None is being made in America at this time outside of the Cyanamid company's research laboratory, but abroad various plants are producing some 15 tons of gas per day, part of which goes into high-grade sulphate for fertilizer use and part into anhydrous ammonia. There is also installed and about ready for operation a large Norwegian plant erected for the Birkeland and Eyde interests for transforming some 60 tons of cyanamid per day into ammonia, which will be absorbed in nitric acid for the production of ammonium nitrate. The transformation takes place according to the following reaction:

$$CaCN_2 + 3H_2O = CaCO_3 + 2NH_3$$

This decomposition is accomplished by the use of water and high-pressure steam in autoclaves, and large-scale working plants show an efficiency of over ninety-nine per cent nitrogen transformation. The ammonia gas is delivered from the autoclaves mixed with steam and absorbed directly in sulphuric acid without removal of the steam, or passed through a very small ammonia column equipped with condensers and coolers for the removal of the steam, thereby yielding a very high-grade pure ammonia gas. In case it is desired to make anhydrous ammonia it is simply necessary to intensify this drying action and compress the gas; considerable quantities of this ammonia are sold in France in the anhydrous state. The cost of the transformation is almost negligible, as the units have very large capacity and require very little attention.

Cyanamid in the presence of water tends to transform itself slowly to dicyandiamid, and this latter to urea. Methods have been recently evolved which make practicable these transformations either to urea or dicyandiamid with approximately 90 per cent efficiency and obtain chemically pure salts as the end product. Dicyandiamid, formula H_2CN_2, contains 66.6 per cent nitrogen, or probably the highest concentration of any staple nitrogen compound. It has been proposed for use in explosives, acting as a deterrent, also for use in the dye industry. Its greatest future possibly lies in the ease with which acids transform it into the guanidines, which should find large uses in the explosive industry. The material has been proposed for use as a fertilizer because of its high nitrogen content, but it is probable that its slow decomposition in the soil will never warrant its use for this purpose.

The United States is importing about $50,000 worth of high-grade urea annually for the celluloid industry alone, and could this material be cheaply produced there is no doubt but that it would find an even greater use in the explosive industry. Considerable quantities of this material have been produced in the research laboratory, which has been tried by the celluloid manufacturers with perfect success. It is now practicable to replace the importations of this expensive salt.

In the field of organic derivatives of cyanamid there is practically no end to the series that have developed abroad. The latest addition to this group has been

creatin, which seems to be getting somewhere close to synthetic foods.

The calcium in the calcium cyanamid can be replaced by the heavy metals, and recent experimenting with some very interesting compounds, such as lead cyanamid and copper cyanamid, promise valuable results.

When certain grades of cyanamid are melted with common salt the free graphite in the original material is combined with the calcium cyanamid, forming cyanide. A transformation of better than 90 per cent nitrogen efficiency is obtained and the resulting product contains approximately 25 per cent KCN equivalent. This material, which can be prepared so as to deliver it into the hands of the consumer at about two-thirds the present price of high-grade cyanides, requires solution in water and filtration. Both operations are easy, and the filtrate can be used in the place of cyanide for the extraction of precious metals. Large scale experiments have been tried out in various cyanide works throughout the world, and in every case it has proved to be identical in behavior with regular cyanide, showing the same extraction efficiencies. The lower price at which this material can be delivered to the consumer more than takes care of the very simple extra dissolving and filtering operations incident to its use, and there should be, therefore, a very large field for this material, supplanting the more expensive, high-grade cyanides.

Naturally, when the transformation to cyanide is so simple it is also possible to manufacture ferrocyanide, and enter into the case-hardening field and other uses for this material. As a matter of fact, cyanamid itself can be very simply compounded into a case hardener which is the equal of any of the present materials on the market and superior to most of them. The German cyanamid makers have, since the beginning of the war, been swamped with orders for this case-hardening material, sold under the name of "ferrodur."

Reference has been made heretofore in this paper in a general way to nitric acid production from ammonia. There has been developed recently a new process of re-oxidizing ammonia to nitric acid at high efficiency. It is believed to do away with all of the limitations of the Ostwald process and, if so, the industry will be in a position to meet nitric acid demands by way of cyanamid at a cost under conditions existing in the United States below anything any other process can offer. The gases leaving the oxidizing chambers are many times more concentrated than those from the "arc" process furnaces and, therefore, condensation is greatly simplified and recovery much increased. The units can be made large or small and their cost is rather low, so that small nitric acid plants can be installed at almost any place in the country within shipping range of the cyanamid plant, it being autoclaved into ammonia and converted into nitric acid at the point of use.

Quite recently the American Cyanamid Company has been using the "cyanamid" process as a means of producing argon gas in quantities, producing the nitrogen by means of the copper process and later eliminating the nitrogen by continued re-absorption in the cyanamid ovens, leaving argon as the final gas. Thousands of feet of this gas, highly concentrated, is being sold to the lamp industry, chiefly for American use, but in part to consumers abroad.

Atlantic City Meeting of the American Electrochemical Society

The twenty-seventh general meeting of the American Electrochemical Society was held in Atlantic City, N. J., on Thursday and Friday, April 22 and 23, and was concluded in Philadelphia on Saturday, April 24. Since Atlantic City has no local members, the attendance was somewhat less than usual (the number of those who registered being 130), nor was there any official smoker or banquet, but the meeting will be remembered as the one which among the many lively meetings of this society, has produced the most lively and extended discussions, and in the crisp spring air the Atlantic City board walk was enjoyed at its best in spite of an occasional little shower during sessions. When a session closed the sky would clear up.

The hotel headquarters were at the Chalfonte, where all sessions were held.

Thursday Session.—Business Meeting

The annual business meeting was called to order by President Lidbury on Thursday afternoon. The secretary of the society, Dr. Joseph W. Richards, read the annual report of the Board of Directors. The membership at the end of 1914 was 1377 and twenty-nine new members have been elected since the first of the year. Reports of the different committees were then presented and the report of the tellers of election was announced as follows:

Mr. Lawrence Addicks, of Douglas, Ariz., is the new president. Messrs. L. E. Saunders, John A. Mathews and L. Kahlenberg were elected vice-presidents. Messrs. L. D. Vorce, William Acheson Smith and William H. Walker were elected managers. Mr. P. G. Salom was re-elected treasurer, and Dr. Joseph W. Richards of Lehigh University, South Bethlehem, Pa., was re-elected secretary.

Mr. Lawrence Addicks, the new president, was born in Philadelphia, Pa., on March 3, 1878. He was educated at the University of Pennsylvania and at the Massachusetts Institute of Technology from which he graduated in 1899 in both the mechanical and electrical courses. He went to New Mexico, where he was employed in a copper mine, but returned East in 1900 to become assistant to the superintendent at the Raritan Copper Works. In 1905 he became chief engineer and a few months later superintendent of the U. S. Metals Refining Company of Chrome, N. J. He was the superintendent of this copper refinery for nine years. In 1914 he became connected with Phelps, Dodge & Company to conduct the large-scale leaching tests on low-grade copper ore at Douglas, Ariz. Mr. Addicks is recognized as one of the highest authorities on electrolytic copper refining and has presented numerous papers before the American Electrochemical Society, the American Institute of Mining Engineers, the American Institute of Electrical Engineers and other technical and engineering societies.

Presidential Address

The retiring president, F. A. Lidbury, works manager of the Oldbury Electrochemical Company, Niagara Falls, then presented his very able and interesting presidential address on the American Electrochemical Society in Its External Relations, which is published in full on page 277, of this issue.

Fibrox

A paper by Dr. E. W. Weintraub, of the General Electric Company, Lynn, Mass., deals with the preparation and properties of fibrox, which is the name given by the author to a fibrous material of the composition of silicon oxycarbide. The name is to suggest the remarkable structure of the material. The author first reviews former work done on amorphous silicon oxycarbides by various investigators from Schuetzenberger to Tone and then describes the manufacture as follows:

A muffle (or pot) of material capable of withstanding a temperature of 1400 deg. to 1500 deg. C., having its bottom covered with a layer of silicon pieces, is heated in a gas furnace to the temperature of incipient melting of silicon. A muffle of Dixon graphite clay-lined has proved to be suitable. The ends of the muffle protruding outside the furnace are luted on to the muffle in a gas-tight manner. It is essential that a catalytic agent be used. One such agent is calcium fluoride.

After a run of a few hours the muffle is found filled completely with fibrox, which is removed and the operation repeated. It is only necessary from time to time to break up the slag which forms on the surface of the silicon and to add some fresh fluorspar or other catalyzer.

It is obvious from the process described that fibrox is a product of slow and quiet growth, and from its composition it must be formed when silicon vapors and carbon dioxide or carbon monoxide react. The silicon vapors come from the silicon. The carbon dioxide comes from the combustion gases of the furnace. One has, therefore, to picture to himself the oxide of carbon slowly diffusing through the pores of the vessel and reacting with the silicon vapors. This slow interpenetration of the reacting gases through a permeable wall is an important feature of the process and is essential if the finest structure is to be developed.

The fluorspar or other catalyzer used has most probably the function of keeping the slag (silica?) in a sufficiently soft condition to allow the silicon to "seep" through it and expose a clean surface from which the silicon vapors can freely escape.

The most remarkable thing about fibrox is its physical structure. It is a soft, resilient, fibrous material; after general compression it returns to its original shape; it can be cut into plates, sheets, and rings which are self-supporting. The material is an agglomeration of exceedingly fine fibers much thinner than fine hair. The diameter of the fibers is in average about 0.6 micron, or about the wave length of yellow light. Some fibers are undoubtedly smaller and probably approach 0.3 micron.

The apparent density of the material, while varying with the circumstances, is usually between 0.0025 and 0.0030. In other words, it weighs only about $2\frac{1}{2}$ to 3 grams per liter. The real density of the material varies with its composition. When the composition corresponds nearly to the theoretical silcon oxycarbide SiCO (about 21 per cent. of carbon), the real density is 1.84. As the carbon content diminishes the real density increases up to about 2.2 or nearly that of silicon. From the real and apparent density, the actual volume occupied by air is figured out to be over 99.5 per cent. and in the best cases equal to 99.9 per cent. and that of the solid material is only between 0.5 and 0.1 per cent.

For the temperature interval of 100 deg. to 15 deg. a long-fiber dark-green sample of fibrox compressed to a density of 0.767 lb. per cubic foot or 12.3 grams per liter has a resistivity in degrees per watt, per inch cube, $R' = 1675$, or per cm. cube $R = 4200$. A comparison with other materials will be instructive. For wool at a somewhat higher density of 0.955 and the same temperature interval R' (in. cube) $= 802$ ($R/cm.$ cube $= 2000$) and at a density of 3.4, $R' = 110$ ($R/cm.$ cube $= 2700$). Wool has to be compressed to a density of 12 pounds per cubic foot or more than 15 times that of fibrox to get the same value of heat resistivity. Eiderdown reaches a value equal to that of fibrox at a density of 5, or more than 6.5 times the density of fibrox. Among the inorganic heat insulators, monox has a density of 6.18, $R' = 1000$ ($R = 2500$) and "Elephant Ear" at a density of 8.4, $R' = 1100$ ($R = 2700$). It will be seen that by its value of heat resistivity fibrox stands in a class by itself. The heat insulating values decrease with higher temperatures. While fibrox is the best heat insulator, it is a relatively good electrical conductor with a conductivity comparable to that of electrolytic solutions. This is most remarkable.

Dr. Weintraub exhibited samples of this most interesting new heat-insulating material. While nothing definite yet can be said concerning the price at which it will be sold, it seems certain that the price will not be prohibitive, as it may be possible to sell the cubic foot at 50 cents, when fibrox is placed on the market.

In the extended discussion which followed Mr. Tone spoke of his own work in this line and said that his silicon oxycarbide differed from fibrox in degree, but not in kind, and Mr. Arthur spoke of similar work done at the Schenectady laboratory of the General Electric Company. Mr. Northrup referred to filtering possibilities and Messrs. Baekeland, Hitchcock, Franklin, Taylor, Mott, Hering, Richards, Frary continued the discussion. While Dr. Weintraub makes fibrox in a gas-fired furnace, Mr. Saunders expressed the opinion that fibrox could be made in an electric furnace.

LAWRENCE ADDICKS, PRESIDENT
AMERICAN ELECTROCHEMICAL SOCIETY

Thermal Conductivity of Refractories

A paper by Professor Boyd Dudley, Jr., of the Pennsylvania State College, deals with "the methods and results of an investigation designed to develop a practical and reasonably accurate means of determining the thermal conductivity of regular kinds of brick, under conditions approaching those of practice and without the necessity of preparing special shapes or samples of the materials being tested." The author

first gives a classification and review of the various methods which have been devised to measure the heat conductivity of refractories and then describes his own method.

This method of determining thermal conductivities consists of using the brick under test in the construction of one single wall of a specially constructed coke-fired furnace, and measuring the rate of heat flow through a certain area of the test wall by means of a water jacket applied to the cold side. Temperature measurements are made at various points in the brick, and from the data thus secured the conductivity of the material constituting the wall is calculated. The advantages of the method are these: Special shapes or test pieces of the refractory are not needed, the tests being made on samples of commercial brick. The conductivity is readily calculated from the observed data without recourse to complicated factors involving the shape of the conducting body. Variation of the conductivity with temperature is made apparent by graphic representation of the temperature gradient through the brick.

The furnace consists of three permanent walls, one side and two ends, provided with a permanent roof and stack connection. These three walls are constructed of fire brick and tile, and are each 9 inches thick. The roof of the furnace and stack connection are supported from the end walls on iron bars placed as shown. The fourth wall (the front side of the furnace) is independent of the other parts of the furnace and is built of the brick to be tested. The fuel used is sized by-product coke, which is charged through the fire door at the top of the back side of the furnace. The grate consists of four iron bars. Air enters under the grate, and additional air is drawn through openings in the back side of the furnace. These openings may be closed or left open as is necessary; it is found that by regulating the amount of air entering the furnace at the various points it is possible to secure rapid combustion of the coke, from the top of the bed of fuel to the grate, a depth of about 26 inches. In this manner a sufficiently large area of the test wall is heated to a uniform temperature to render permissable the use of a calorimeter 1 foot square.

Concerning the details of the arrangement and especially the construction of the calorimeter with which the rate of heat flow through the wall is measured, the reader is referred to the complete paper to be published in the Transactions of the Society.

The method was applied by the author to tests of four types of refractories. The kinds of brick tested were first-quality fire-clay brick, silica brick with clay bond, silica brick with lime bond and magnesite brick. All were manufactured by the Harbison-Walker Refractories Co., Pittsburgh, Pa.

Details of the composition of the different bricks are given in Table I.

TABLE I.—ANALYSIS OF BRICK

Per Cent	Woodland	Quartzite	Star Silica	Magnesite
SiO_2	52.93	73.91	95.85	2.50
Al_2O_3	42.69	22.87	0.88	0.50
Fe_2O_3	1.98	1.48	0.79	7.00
CaO	0.33	0.29	1.80	2.75
MgO	0.38	0.31	0.14	86.50
Alkalies	1.55	1.20	0.39	....
Loss on ignition....	....	....	....	0.10
Apparent density ...	1.91	1.91	1.56	2.46

The results of the measurements of heat conductivities are given in Table II.

TABLE II.—HEAT CONDUCTIVITIES OF BRICK

Material	Test No.	Exp. Temp. Range	Mean k Over Exp. Range	Calc. k at 100°	Calc. k at 1000°
Woodland ...	1	120 to 965	0.00676	0.00532	0.00816
Woodland ...	2	100 to 1025	0.00666	0.00438	0.00880
Woodland ...	3	400 to 995	0.00704	0.00332	0.00886
Quartzite ...	1	100 to 935	0.00679	0.00504	0.00880
Quartzite ...	2	100 to 960	0.00670	0.00521	0.00836
Star silica ...	1	100 to 910	0.00794	0.00561	0.0108
Magnesite ...	1	445 to 830	0.0343	......	0.0343

The third column gives the temperature range in deg. C. for each test. The fourth column gives the mean conductivity k for this temperature range in gram calories per second per inch cube per deg. C. Columns 5 and 6 give calculated values of the heat conductivities k at 100 deg. and 1000 deg. C. respectively.

While the calculated conductivities are in some cases not in close agreement, in general they are consistent in indicating the relative conductivities of the various materials. Taking the averages of the figures applying to each material the conductivities at 100 deg. and 1000 deg. C. are given in Table III in gram calories per second per inch cube per deg. C.

TABLE III.

Material	Average k at 100 deg.	Average k at 1000 deg.
Woodland	0.0043	0.0086
Quartzite	0.0051	0.0086
Star silica	0.0056	0.0108

For magnesite brick it was found that between 445 deg. and 830 deg. C. the conductivity of the magnesite brick was practically constant, the value being 0.0343 gram calories per second per inch cube per deg. C. For this reason magnesite brick is not included in the above Table III.

It is estimated that the precision of the figures representing mean conductivities is within 5 per cent. The precision of the average figures representing the conductivities at definite temperatures is less, but it is difficult to estimate.

In the absence of Professor Dudley, his paper was presented by Dr. Richards. It was discussed at some length by Messrs. Hering, Schluederberg, Hitchcock, Addicks, Chapin, Northrup, Frary, and Richards. Dr. Hering pointed out that Dudley's method of measurement gives directly the heat conductivity of the solid material and eliminates the surface resistance to flow of heat. This additional resistance may become important in practice. Mr. Hitchcock replied that the thermal resistance of the solid material is really what is wanted by the practical man; he plotted curves to show that the additional surface resistance is relatively insignificant. Dr. Northrup emphasized the altruistic character of such heat-conductivity experiments with their immense technical difficulties and the enormous expense of time they require.

Reaction Between Graphite and Magnesia

A paper by Professor **O. L. Kowalke** and Mr. **D. S. Grenfell**, of the University of Wisconsin, gave an account of measurements of the temperature of reaction between Acheson graphite and magnesia.

Three different methods were used: In the first method, weighed samples of the two materials—magnesia and graphite—were heated in contact with each other for half an hour at various temperatures and the loss in weight determined.

The second method was based on the fact that the reaction is endothermic. When the substances attain the reaction temperature, heat will be absorbed from the surroundings and the temperature falls, which becomes manifest in the pyrometric curves.

The third method employed a vacuum furnace; the beginning of the reaction would be detected by an increase in pressure.

The second method gave the best results. The pyrometric curves indicate that the reaction commences slowly at about 1950 deg. C. and becomes very violent at temperatures above 2030 deg. C.

The paper which, in the absence of the author had been presented by Professor Frary, was discussed by

PHOTOGRAPH TAKEN AT ATLANTIC CITY MEETING OF AMERICAN ELECTROCHEMICAL SOCIETY

Messrs. Bennett, Northrup, Hinckley, Whitney, Richards, Mott, Hitchcock, Frary, Saunders and FitzGerald. The latter thought that such reaction temperatures are rather indefinite.

Analogies Between Electricity and Mechanics

In the evening of Thursday, Professor **W. S. Franklin** of Lehigh University, presented a most interesting experimental lecture on "some mechanical analogies in electricity." The principal object was to show some exact analogies between rather difficult yet fundamental conceptions in alternating-current engineering and well-known mechanical conceptions. Professor Franklin showed especially the analogy between induction in electromagnetism and inertia in mechanics and the analogy between a condenser in electromagnetism and and an elastic medium in mechanics.

Professor Franklin's experiments were striking and the audience was still more impressed by the decidedly original viewpoint of the lecturer, which may be indicated by his quotation, made in concluding the lecture, from his recent little textbook "Elementary Electricity and Magnetism" (Macmillan Co., 1914, page 56):

"Electricity or energy; which? When water is pumped through a pipe it is usually the amount-of-water-delivered-in-a-given-time that is important. The amount of power represented by the stream of water is of no great importance. It is the water itself that is useful, and the power expended in driving the pump is merely enough to carry the water where it is needed. But one might conceivably use a pump to drive water through a circuit of pipe for the sake of the heating effect of the moving water in the pipe or to drive a water motor placed anywhere in the circuit of pipe. In such a case one would be interested primarily in the amount of power represented by the stream of water because the desired effect (heating or motor driving) would depend upon the amount of power.

"So it is in the case of the electric current. It is not 'electricity' (whatever that is) that one uses, it is work or energy; and the important thing about an electric generator (a battery or dynamo) is the amount of power represented by the electric current delivered by the machine. This may be illustrated most pointedly as follows: A wheel drives another wheel by a belt. A person knowing nothing at all about machinery and especially a person having no available words to use in describing such an arrangement, might look at the continuous stream of leather given off the first wheel and decide to call this wheel a leather generator! Everyone knows, however, that a driving wheel does not generate leather; it gives off energy work and the work is transmitted to the driven wheel by the belt. It seems very ridiculous to speak of a belt-wheel as a generator of leather, and indeed it is equally absurd to speak of a battery or dynamo as a generator of electricity. One must be careful not to take electrical terms and phrases too literally.

"To speak of a dynamo as an electric generator is, however, not seriously objectionable, but to speak of 'electricity' as a motive power indicates a very serious misunderstanding. When it is proposed to drive a machine by a leather belt it is always understood that something must drive the belt, but when it is proposed to drive a machine by 'electricity' it is not always understood that something must drive the 'electricity'. Electricity as applied in the arts is merely a go-between like a leather belt, and no one ever thinks of leather as a motive power!"

Friday Morning Session.

The Friday morning session was opened by the presentation of two papers by Dr. W. D. Bancroft, of Cornell University, on colloidal chemistry. In Professor Bancroft's absence the first paper was presented by Dr. Whitney, the second by Professor Frary.

Coagulation of Albumin by Electrolytes

A paper by Professor **Wilder D. Bancroft,** of Cornell University, reaches the following conclusions:

So far as the data go the coagulation of albumin by salts can be accounted for more satisfactorily on the assumption that we are dealing primarily with

adsorption rather than on the assumption that we are dealing primarily with an amphoteric electrolyte.

Slightly acid or slightly alkaline solutions of albumin are least stable when the dispersed phase is electrically neutral.

Since the sign of the electrical charge depends on the preferential adsorption of cation or anion, the nature of both anions and cations is important.

When albumin is charged positively, the most strongly adsorbed anion will be most effective in causing precipitation and the most strongly adsorbed cation in preventing precipitation.

When albumin is charged negatively, the most strongly adsorbed cation will be most effective in causing precipitation and the most strongly adsorbed anion in preventing precipitation.

If one adds to negatively charged albumin a salt consisting of a readily adsorbed cation and a slightly adsorbed anion, we shall get precipitation at low concentration and no precipitation at higher concentration; but in this latter case the albumin will be charged positively.

While the reversibility of precipitation depends in part on the ease with which the precipitating agent can be washed out, it seems probable in the case of albumin that the physical properties of the precipitate are important as determining coalescence and agglomeration. There are no data on this point.

In the case of electrolyte-free albumin one must apparently assume that the stability of the solution is due to the peptonizing action of water in the absence of electrolytes.

The coagulation of albumin by electrolysis is a typical and general case, whereas the coagulation of gold sols and ferric oxide sols are special cases.

Neutralization of Adsorbed Ions

A paper by Professor **Wilder D. Bancroft,** of Cornell University, reaches the following conclusions:

The neutralization of an adsorbed ion is due to specific adsorption. The concentration of a given electrolyte necessary to neutralize the charge on a given colloid will therefore depend on the nature of the cation, the anion and the colloid.

It is inaccurate to say that the cation is negligible in the precipitation of a positive colloid and the anion in the precipitation of a negative colloid, though this statement is often approximately true.

Univalent ions are not all adsorbed alike; nor are bivalent ions or trivalent ions. The order to adsorption is specific with each colloid and is not determined exclusively—and perhaps not at all—by the migration velocity or solution pressure of the ion.

Since the adsorption is specific, Schulze's law is only an approximation. Certain univalent ions are adsorbed by certain colloids more than certain bivalent or trivalent ions. In many cases there is, however, a marked tendency to increased adsorption with increasing valence.

Mixtures of two sols will not precipitate each other unless adsorption takes place.

Since adsorption is specific, the order of precipitation of a negative sol by a number of positive sols will not necessarily be the same for any two negative sols.

It is not accurate to say that two sols having the same sign have no effect one upon the other. Adsorption may and often does take place.

Hydrous chromic oxide, which is peptonized by caustic potash may act as a protecting colloid for hydrous ferric oxide, which is not peptonized by caustic potash.

Since an adsorbed ion does not necessarily give the reactions of a free ion, electrometric measurements may and do lead to false conclusions when applied to colloidal solutions.

It is probable that sodium palmitate solutions are hydrolyzed to a very much greater extent than appears from electrometric measurements.

If two colloidal sols did not adsorb each other appreciably and if one adsorbed the cation of a given electrolyte very markedly, while the other adsorbed the anion of the same electrolyte very markedly, the addition of a small amount of the electrolyte to a mixture of the two colloids would produce a solution which would conduct electricity without their being any appreciable amount of substance in true solution.

In sodium palmitate solutions, it seems probable that the hydroxyl ions set free by hydrolysis are adsorbed practically completely by the colloidal soap.

Addition of a colloid to a solution will increase or decrease the conductivity if the adsorbed ion has a greater or smaller migration velocity than the ion adsorbed. In so far as both ions are adsorbed the conductivity will decrease.

When adsorption by a colloid causes hydrolysis the conductivity will depend also on the nature of the products of hydrolysis.

The two papers elicited a very interesting discussion on colloidal chemistry in general in which Messrs. Whitney, Cox, Lidbury, Franklin, Jacobs, Mott, Frary and Taylor participated. One one side Dr. Whitney emphasized the enormous present importance of the development of colloidal chemistry where new and important results are constantly obtained, especially in the explanation of biological phenomena, for instance, the action of the heart, and President Lidbury urged that while in the past biologists had almost monopolized the field of colloidal chemistry, electrochemists should now

TABLE I—THERMO EMF OF IRON-NICKEL ALLOYS.
(AGAINST COPPER. 0 TO 100 DEG.)

Fe	Ni	Si	C	T. E. F. Millivolts
100.	......	......	......	+ 0.86
83.	17.	......	......	— 0.64
80.	20.	......	......	— 0.55
70.	30.	......	......	— 0.52
66.5	33.5	0.16	0.25	— 0.48
18.8	81.2	0.014	0.19	— 2.45
7.	93.	......	......	— 1.90
4.6	94.6	0.64	0.11	— 1.40
3.2	96.3	0.35	0.12	— 2.00
.....	100.	......	......	— 2.38

TABLE II—THERMO EMF OF IRON-CHROMIUM ALLOYS.
(AGAINST COPPER. 0 TO 100 DEG.)

Fe	Cr	T. E. F. Millivolts
90.	10.	1.20
82.	18.	1.04
80.	20.	0.43
76.5	23.5	0.32
70.5	29.48	0.31

TABLE III—THERMO EMF OF IRON-COBALT ALLOYS.
(AGAINST COPPER. 0 TO 100 DEG.)

Fe	Co	T. E. F. Millivolts
90.	10.	— 0.64
80.	20.	— 3.70
70.	30.	— 3.50

TABLE IV—THERMO EMF OF IRON-NICKEL-CHROMIUM ALLOYS. (AGAINST COPPER. 0 TO 100 DEG.)

Fe	Ni	Cr	Mn	Si	C	T. E. F. Millivolts
79.	17.	4.	...	...	...	— 0.12
70.	20.	10.	...	...	...	— 0.46
35.	55.	10.	...	...	...	0.00
25.	60.	15.	...	...	...	0.07
25.	55.	20.	...	...	...	0.07
20.	55.	25.	...	...	...	— 0.08
17.5	75.5	7.	...	0.03	0.22	0.20
16.3	70.6	13.1	...	0.02	0.17	0.20
16.3	70.6	13.1	...	0.02	0.20	0.17
9.6	57.7	31.9	0.20	0.30	0.40	— 0.08
6.4	69.	22.7	0.30	0.25	0.20	0.24
5.	84.	11.	...	0.40	0.034	1.49
4.5	81.	13.6	0.30	0.30	0.17	1.00
4.	89.6	5.65	...	...	...	1.70
4.	80.4	15.6	...	0.58	0.23	0.76
3.8	89.7	5.6	0.25	0.40	0.18	1.51

make this field their own. On the other hand, Professor Frary, in presenting Dr. Bancroft's second paper, showed how in various instances the point of view of the "old chemistry" was able to explain matters quite as successfully as the colloidal chemist's viewpoint. The whole discussion not only contributed to a more general understanding of such conceptions as adsorption, as distinguished from absorption, but undoubtedly created a broader interest in colloidal chemistry.

Thermo-Couples

A paper by Mr. **T. S. Fuller,** of the Research Laboratory of the General Electric Company, Schenectady, N. Y., gave the results of the measurement of "the thermo emf of certain iron alloys." The methods employed were described and the results given in tables and diagrams. The results for iron-nickel, iron-chromium, iron-cobalt, iron-nickel-chromium and iron-nickel-manganese are given in Tables I, II, III, IV and V.

TABLE V—THERMO EMF OF IRON-NICKEL-MANGANESE
ALLOYS. (AGAINST COPPER. 0 TO 100 DEG.)

Fe	Ni	Cr	Mn	Si	C	T. E. F. Millivolts
87.	10.	. . .	3.	. . .	. . .	— 1.09
86.	12.	. . .	2.	. . .	. . .	— 1.02
81.	17.	. . .	2.	. . .	. . .	— 1.50
80.	17.	. . .	3.	. . .	. . .	— 0.79
76.5	17.5	. . .	6.	. . .	. . .	— 0.73
76.	22.	. . .	2.	. . .	. . .	— 1.84
50.	44.	. . .	6.	. . .	. . .	— 0.59
43.6	58.3	0.31	6.6	1.	0.16	— 0.94
5.	82.8	0.11	12.	0.058	0.068	— 1.11
5.	88.5	0.11	6.2	0.061	0.065	— 1.60

The paper was discussed by Messrs. Fink, Mott, Gillett, Jacob, Whitney, Richards, Hinckley, Ruder, and Fuller. The hope was expressed that these measurements would be extended to higher temperatures.

LeClanche Cells

A paper by Professor **M. deKay Thompson** and **Ernest C. Crocker** of the Massachusetts Institute of Technology deals with the depolarization in LeClanche cells.

In the LeClanche cell the positive electrode consists of carbon in contact with manganese dioxide. The dioxide acts as the depolarizer, but does not depolarize completely, as is shown by the gradual decrease in the current and voltage on closed circuit. LeClanche recommended that the manganese dioxide should be mixed with carbon and that both should be coarse in size. LeClanche cells, in various forms, are extensively used at the present time, especially as dry cells. About fifty million a year are manufactured in the United States alone. Wet cells are also made in smaller quantities.

In view of the considerable difference in sizes of the depolarizer particles, used in different makes of LeClanche cells now in commercial use, the authors made a study of the comparative efficiency of depolarizing mixtures of carbon and manganese dioxide, when the sizes of the particles and the relative amounts of the substances present in the mixture were varied. The chief result of their investigation is that the carbon and pyrolusite particles should have the same size, and this should be such as to allow the particles to pass through openings 1/10 inch (0.25 cm.) square and not to pass through openings 1/120 inch (0.02 cm.) square.

The purity of the pyrolusite affects the depolarization materially. The mixture of carbon and pyrolusite should contain 55 to 60 per cent pyrolusite.

In addition, the authors investigated the cause of polarization in LeClanche cells. It is assumed to be due to the decomposition of the anmmonium radical and its subsequent splitting up, represented in the equation $2NH_4 = 2NH_3 + H_2$. The polarization

may, therefore be due either to hydrogen or to ammonia. The investigation shows that the polarization by hydrogen is completely prevented by the manganese dioxide. The remaining depolarization in the LeClanche cell is due to ammonia. This may be largely overcome by the addition of zinc chloride to the solution.

Communicated discussions by Professor Burgess and Dr. Cheney were read and Messrs. Richards, Frary, Whitney, Hitchcock and Franklin participated orally in the discussion. It was pointed out that pyrolusite is a rather variable mineral. Further attention was called to the fact that university professors have to undertake such work, because the commercial companies which have all this information in their files would not publish it.

Copper Leaching

The concluding number on the program of the Friday morning session was a general discussion of leaching of low-grade copper ores with subsequent electrolytic precipitation. This had been the subject of an extended discussion on Jan. 6, 1915, at a joint meeting of the New York sections of the American Electrochemical Society and the American Institute of Mining Engineers. In view of the representative character of the engineers who took part in that discussion, it was of unusual value, being a condensed statement based on wide experience. At Atlantic City a review of the chief results of this discussion was given by Mr. Addicks. We will first give a rather full account of the original New York City discussions and follow this by an account of the additional discussion at Atlantic City.

Discussion in New York

Dr. L. D. Ricketts opened the discussion, expressing his deep interest in the subject and in the value of free discussion by men having special qualifications to consider different phases of the work. He outlined the problem existing at the New Cornelia property at Ajo., Arizona, where there is about 40,000,000 tons of ore containing $1\frac{1}{2}$ per cent copper; 12,000,000 tons is oxidized, 24,000,000 tons sulphide, and about 4,000,000 tons is a mixture of the two classes. Other large tonnages of oxidized ore of low grades were mentioned showing the importance of their treatment.

In our issue for September, 1914, page 591, we presented an abstract of Mr. Stuart Croasdale's paper read at the Salt Lake meeting of the A. I. M. E., giving the results of his experiments on the New Cornelia ore. This ore has a matrix of granite with a large percentage of secondary quartz replacing felspar. There is little calcium present in soluble form, and the oxidized seems adapted to a leaching process.

"Preliminary laboratory tests showed that the ore crushed with the production of remarkably little slime and that the copper will dissolve in dilute sulphuric acid quite freely when the crushed ore contains fragments no larger than 6-mm. cubes. Tests also showed that a little cuprite is present, which is only partly soluble in sulphuric acid. There are also other soluble salts, notably salts of iron and aluminum. It was decided to investigate a leaching process for the oxidized ore, and since the ore made but little fines and could be leached with comparatively coarse crushing, we decided that we would try to leach in tanks by percolation. The amount of silver in the ore is small. Salt is apparently expensive, and it was decided that, other things being equal, the use of chlorine compounds as solvents was not desirable.

"Mr. Croasdale demonstrated that the ore crushed to an 8-mm. cube, or smaller, would yield over 80 per cent of its copper when treated with a dilute solution of sulphuric acid. He demonstrated that slime

presented no difficulty if the ore was distributed in the tanks uniformly, and that by finer crushing 85 per cent of the copper could be obtained in solution if treated for a sufficient length of time with an acid solution. He demonstrated not only that the ore was permeable uniformly, but that with comparatively small tanks the height was not a matter of great consequence, and he was easily able to use a column 12 ft. in height, and could probably use one much higher. Later on we found upward percolation preferable.

"Mr. Wedge showed us that with care in calcining the sulphide fines for reverberatory furnaces at the Calumet & Arizona smelter at Douglas, sulphuric acid of 55° to 60° B. could be manufactured with a low operating cost, and a construction cost of not to exceed $3,000 per ton of daily capacity. The point of manufacture is about 300 miles, more or less, according to the route, from the mine. Mr. Wedge also undertook a study of sulphating and chloridizing roasts. His requirement were that the ore be crushed to pass a $1\frac{1}{2}$-mm. screen. He showed that if the sulphide ore could be mined in parallel with the oxidized ore, and in proportion to their respective tonnages, there would be sufficient sulphur for his purposes and that a very high extraction could be obtained. He also showed that sufficient advantage could not be had in using salt to offset its cost and the difficulties that might arise later. Mr. Wedge also showed that a small amount of heavy sulphides from the Bisbee mines crushed and mixed with the oxide ore would give a very high percentage of extraction after the mixture had been subjected to a sulphating roast. He also introduced the idea that a preliminary water leach would give a perfectly pure sulphate solution from which the copper could be recovered electrolytically and that the acid thus regenerated would be sufficient to complete the leach."

Reference was made to the experimental work of Mr. Laist, at Anaconda, where is was found that by calcining sulphide or mixed ores a high percentage of copper could be extracted by leaching. Temperature control was shown to be vastly important, by both Messrs. Wedge and Laist. Mr. Ricketts made reference also to the McKay process, using a sulphatizing roast to render copper soluble; also the slater and Midland processes, which depend on the use of complex chlorides and hypochlorous compounds to attack copper compounds not affected by sulphuric acid.

"At the beginning of our investigation we seriously considered what I called the 'brutal method' of leaching, namely, the manufacture of sulphuric acid, the solution of the copper from the ore with such acid, and the precipitation of the copper by metallic iron, with the resultant complete, or nearly complete, destruction of both acid and iron and the production of an impure cement copper that will have to go through the process of smelting and refining. The results of Mr. Croasdale's tests and Mr. Wedge's cost figures indicated that such a course was commercial, and we concluded that the $1\frac{1}{2}$ per cent Ajo ore, with no overburden, mined by steam shovel and crushed coarse, would yield a profit on a 12c. copper market if a cheap grade of Alabama pig iron were used.

"But it occurred to me, as it had occurred to many engineers, that oxide of iron could be reduced to metallic iron without fusion, and if so we might bring Bisbee sulphides to the mine, calcine them for the manufacture of sulphuric acid and then metallize the available iron in the impure calcine, already containing values requiring recovery, and use this for a precipitant."

The experiment of metallizing was tried in a small

Wedge furnace, but was a failure because in keeping the charge hot the CO_2 formed was sufficient to retard and reverse the action of CO in reduction. Experiments in revolving cylinders, using illuminating gas and fuel oil in a continuous process, also were a failure. Mr. Laist, however, had demonstrated that sponge iron could be made in a revolving drum by an intermittent process. Mr. Ricketts became convinced that the use of iron, with destruction of both iron and acid, was preposterous, and decided to investigate electrolytic processes of deposition, and later the precipitation of copper by sulphurous acid gas.

PRECIPITATION BY SULPHUROUS ACID GAS

"In the precipitation of copper by sulphurous acid gas, temperature and consequent pressure must be considered. If the copper is precipitated in metallic form this temperature and pressure are very high, but if a sub-chloride of copper would satisfy us, the temperature and pressure may be moderate. In both of these processes, the reactions we are familiar with in the formation of sulphurous acid by treating copper turnings with concentrated sulphuric acid are reversed by heat. For the production of metallic copper the action depends upon getting sulphurous acid dissolved in the sulphate solution in sufficient amount to precipitate the copper and then heating the mixture under proper control to about 150° C. The question of the use of an abnormally rich gas is involved. Under proper regulation pure copper is produced, which only needs melting for the market, and a large excess of sulphuric acid is formed. Mr. Van Arsdale has done valuable original work on this process, followed by the work of Weidlein and others in its commercial development. Laist has studied precipitating sub-chloride of copper. A soluble chloride is added to the sulphate solution of copper and the proper amount of sulphurous acid is added. Moderate heat under pressure—90° C. of heat—precipitated almost all the copper as sub-chloride. The subsequent process of obtaining the copper without volatilization and the recovery of the chlorine offered difficulties. It is with no disparagement of the process that we have abandoned it in our case. To me and my friends the electrolytic method seemed best adapted to our condition and the simplest and more certain of commercial application.

INVESTIGATION OF ELECTROLYTIC METHODS

"Of course, the first difficulty was the solution of other oxides than copper and the danger of some loss of acid thereby, and, what was more important, the susceptibility of some of these dissolved neutral salts to oxidation by nascent oxygen to the production of acid salts, which in turn will dissolve copper from the cathode. It seems that such salts are most valuable as depolarizers, but must be held under control."

Mr. F. L. Antisell and Messrs. Pope and Hahn were employed to make a series of tests and experiments covering the difficulties offered by iron and aluminum.

"Both Mr. Antisell and Messrs. Pope and Hahn began their experiments upon a laboratory scale at the Raritan Copper Works. Messrs. Pope and Hahn found the leaching could be so conducted that the rate of increase of iron and alumina was slow. They therefore decided to leach in a certain way and to treat a certain high iron and aluminum neutral solution with copper oxides by agitating, heating, and injecting air. This is a rejuvenation of the old Hoffman process applied to a new purpose. The iron and aluminum sulphates in such foul solution, together with arsenic and other impurities, are precipitated as insoluble oxides and the acid previously combined with these

salts is taken over by the copper oxide and forms sulphate of copper. The clarified solution, with these impurities removed, is then mixed with the balance of the solution, thus keeping an iron content of, say, less than ¾ per cent.

"Mr. Antisell began his experiments by using a patent anode. This anode was a narrow, rectangular wooden or lead frame with thin wooden sheets as diaphragms, forming a long and deep but very narrow box. It was packed with a clean coke in lumps crushed to pass a 1-in. ring, and contact was given by carbon rods imbedded in the coke. A solution of sulphate of iron and aluminum in great excess was made up and sulphuric acid added. This was used as a solvent for the copper. After the solution came from the ore it was at first passed to an absorption tower, where sulphurous acid gas was absorbed, and then it passed to the electrolytic tank.

Promising results were obtained in the laboratory, and later tests were made with full sized anodes at Douglas. Excellent results were obtained there also, but difficulty was had with the complete absorption of sulphurous acid. An extraction of 80 per cent was obtained, and 2 lb. copper was recovered per kilowatt-hour. Nearly the theoretical amount of sulphuric acid was produced from the SO_2 gas.

"Mr. Greenway discovered that if a certain copper solution containing salts of triad elements is treated in a simple way, the iron or aluminum triad salts may be removed. Dyad salts are not affected. He was led to the belief that such oxides thus precipitated were in large part insoluble in dilute acid and that therefore he had a very simple method of removing iron and aluminum from the solution. Against my prediction, laboratory tests seemed to show his contention was correct. Mr. Greenway erected a small plant of his own, and a Pope and Hahn plant was installed and the use of sulphurous acid was temporarily discontinued. As for the Greenway process, I am not yet at liberty to discuss it further. But I may say over 100 charges were run with this process. The iron content in the solution was kept down to less than 1 per cent, and we obtained an average of slightly over 1 lb. of copper per kilowatt-hour, but the extraction was low. We then extended the time of the leach and obtained a higher extraction, and finally we began to crush the ore, which at that time had been crushed only to ½-in. ring, finer, and found that if crushed to pass ¼-in. mesh percolation was not retarded and an extraction of over 80 per cent was practicable. The iron has reached as high as 1.2 per cent, but we are still getting a pound of copper per kilowatt-hour from the electrolytic tanks.

"These experiments have been so successful that we are proceeding with the erection of a 40-ton plant, where tanks will be used that will hold 60 tons, if necessary, and will be abundantly large to permit of a study of the comparatively even distribution of crushed ore, and we shall proceed with these most interesting experiments, using first, as we have in the smaller tanks, the Greenway process. In the meantime, the 1-ton plant will be liberated and we will immediately proceed with the continuance of a modified form of the Antisell system of leaching. He finds that with the construction of better absorption towers we can absorb the necessary amount of SO_2 gas, and he has demonstrated that with the use of SO_2 gas, using dyad iron as a depolarizer and triad iron as an oxidizer, he can manufacture sulphuric acid. We can, if successful, obtain 1½ lb., and possibly more, of copper per kilowatt-hour, and at the same time manufacture sufficient acid to replace

wastage. The electrolytic copper in all cases has been fully up to the trade standards.

CONCLUSIONS

"My deductions from a study of the work of the able engineers engaged in these extensive operations are as follows:

1. Dilute sulphuric acid will give a very high extraction on oxidized ores of the Ajo type. Time is a more important element in extraction than strength of acid. A maximum size of 6-mm. cube is required. Such ore crushed to the maximum size permits percolation and the production of a clear solution because the slime content in the ore so crushed is very small.

2. Where such ore is mined at a cost of between 25c. and 50c. a ton, it is commercial on a 12c. market, even if leached with sulphuric acid and the copper precipitated with pig iron to the waste of the acid and iron and the production of an impure cement copper that requires further treatment. Metallized iron from calcines can be made and will prove a little cheaper than pig iron if it is marginal.

3. An electrolytic method for the recovery of pure copper from sulphate solutions is far preferable and will produce cheap copper. In all cases a low current density is required. Hard-lead anodes or composite anodes of hard lead and coke of uniform thickness will be used.

4. Such electrolytic method, with control of the amount of iron and aluminum in the electrolyte, and without the use of sulphurous acid gas, is practicable. An acid loss of about 1.5 lb. per pound of copper will be sustained. Chamber acid will be required.

5. I believe there is a decided probability that the cheapest and best method will be the electrolytic deposition from sulphate solutions without iron control, and the use of the requisite quantity of sulphurous acid. The sulphurous acid will be absorbed without the tank house and in quantity that will not cause annoyance. Iron and aluminum will act both as depolarizers and catalytes. This process promises a high yield of cathode copper per unit of power and the manufacture of sufficient sulphuric acid to replace the waste.

6. While these remarks apply to the Ajo oxidized ore and ores physically and chemically similar, they need not apply to ores of a different composition. Mixed oxide and sulphide ores, be the sulphide chalcocite or chalcopyrite and bornite; ores containing great quantities of clay, or presenting other difficulties, have to be considered separately, and there is beyond question a great field for other processes and for other methods, both for obtaining the copper in solution and obtaining the copper from the solution."

Mr. Utley Wedge called attention to the necessity for making provision for the treatment of the sulphide ore of the New Cornelia, of which there is twice the tonnage that exists of oxidized ore. In his opinion a combination treatment can be evolved that will take care of both types of ore.

"Let the sulphide ore and the ore which is found between the mass of carbonate and the mass of sulphide ore, which partakes of the character of both, be ground to 20 or 30 mesh and furnaced at a temperature not much above a red heat, and the material can at once be leached with as good percentages of recovery as have been secured in the case of the carbonate ore. The copper solutions secured can be electrolyzed, and sufficient sulphuric acid can be produced from the electrolysis for use in leaching all or a portion of the carbonate ore, which methods can be identical with the methods described in the paper.

"I am of the opinion that sulphatizing roasting of

the sulphide ore in the orebody of the New Cornelia Copper Co., coupled with the acid leaching of all or a portion of the carbonate orebody with sulphuric acid by the methods indicated in the paper, will give the lowest possible cost of operation and will give the highest possible recovery of values of any method known to the metallurgical art. This combination of methods would obviate the necessity of construction of a sulphuric acid plant; in the place of this plant there would be constructed a furnace plant for giving the required roast to the sulphide ore. At the start, with only carbonate ore accessible, enough of the carbonate ore could be roasted mixed with small percentages of iron pyrite from neighboring camps to sulphatize the carbonate of copper."

Mr. E. A. Cappelen Smith outlined again the work at Chuquicamata. This has already been published in detail in this journal, May, 1914, page 291. The leaching plant is practically finished, but delay has been occasioned in the completion of the power plant, which is being made in Germany.

Mr. George W. Van Arsdale spoke briefly on the work at Douglas, Arizona, the method used consisting in sulphatizing-roasting, leaching and electrolysis of sulphate solutions, using depolarization.

"The results of our roasting experiments were as follows: We roasted three principal classes of material, in which the average insoluble copper in the calcines was 0.11, 0.16, and 0.41. The water-soluble copper showed 70 per cent of the copper contents, 40 per cent, and 51 per cent, respectively, and the total extraction was 92.9, 88.0, and 70 per cent. One of the principal results of these experiments was to show us that for this class of roasting it was necessary to have more or less fine crushing as a preliminary.

"The results of our preliminary electrolytic experiments were fairly satisfactory. We obtained a total amount of copper precipitated of something over 2 tons at an average figure for power of about 1.6 lb. of copper per kilowatt-hour. We produced acid per kilowatt-hour equivalent to about 5.1 lb. The ampere efficiency was low. This, however, was due to several reasons not directly connected with the process. We had a large number of short-circuits and other troubles, but we felt quite sure at the end of these preliminary experiments that we should get about 2 lb. of copper per kilowatt-hour. We had, however, a certain number of uncertainties and some anomalous results, so we started some further experiments on details of solution and other matters.

"The further experiments resulted in the following general conclusions:

"First, that it was not necessary to have such a large amount of SO_2 in solution as we had previously thought, and that in addition, much better results could be obtained by using SO_2 together with iron, rather than either one alone. In other words, the function of the SO_2 was not only to act as a depolarizer, but also to act chemically in keeping the iron reduced. We also found there was a certain favorable effect from a high aluminum content. The temperature increase is favorable in the same way as in copper refining. With iron salts present there is a decreased ampere efficiency with increased temperature. This was counteracted by SO_2 and by increased current density.

"As a result of these further experiments, we laid down the conditions of high ferrous sulphate in solution, high alumina, a temperature of about 115° to 130° F., current density of about 15 amperes per square inch, and sufficient sulphur dioxide present to reduce the voltage, and maintained sufficiently to keep the iron in the ferrous condition, and under these conditions I expect it will be possible to get a yield of from 2 to 2.5 lb. of copper per kw-hour.

"As to 'foul solutions,' which has heretofore seemed to be the principal bugbear in electrolysis, as long as the iron can be kept in the ferrous state, which can be done by SO_2, it is fairly safe to say that, up to certain limits, better results will be obtained from so-called foul solutions than from pure copper sulphate solution.

"We are now about to start a 75-ton plant, in which we expect to apply the information which we have gained to the treatment of one class of ore, and the result of the work which will be done in that plant will no doubt be published later."

Dr. Raymond F. Bacon, director of the Mellon Institute of Industrial Research, presented the following on methods of precipitation. "Our work on electrolytic processes has been along two lines. First, to ascertain the optimum conditions for the electrolytic precipitation of copper from sulphate solutions obtained by the leaching of oxidized copper ores. In this phase of the work I may say that we finally obtained conditions under which we ran a solution over the ore through the precipitating tanks and then over the ore again, 20 cycles being completed, without any purification of the solution. There was precipitated on the average in these 20 cycles 1.86 lb. of copper per kilowatt-hour and the current efficiency on the twentieth cycle was fully as good as that on the first cycle. Our second line of work on electrolytic processes has been an attempt to find efficient and cheap depolarizers, so as to increase the amount of copper precipitated by a definite amount of electrical energy. We have found one very cheap substance which for short runs gave us 4 lb. copper per kilowatt-hour.

"In regard to the sulphur dioxide process, we have been actuated by this thought—it is necessary in most ores to have quite an excess of acid to take care of mechanical losses and to take care of alkaline substances in the ore. One way of doing this is along the line which has been spoken of, by using the sulphur dioxide in an electrolytic cell. We, also, have used sulphur dioxide in an electrolytic cell, but all of our work has tended to show that the efficiency of sulphur dioxide as an anode depolarizer in a sulphate solution is rather low. Because of this low efficiency, our calculations showed us that it is cheaper to precipitate directly with the sulphur dioxide under pressure than to use the sulphur dioxide as an aid to electrical precipitation; that is, the heat required for direct precipitation with sulphur dioxide will be cheaper in most localities than the electrical energy required either for straight electrical precipitation or for the combination in which sulphur dioxide assists the current. We all appreciate the advantage which any electrolytic process has of giving directly cathodes of electrolytic copper.

DISADVANTAGES OF ELECTROLYTIC PRECIPITATION

"On the other hand, it has seemed to us that for most localities and most conditions the disadvantages of electrolytic processes, as at present developed, outweigh this advantage. Some of the disadvantages of electrolytic processes are these: The fouling of solutions immediately and seriously cuts down the current efficiency. Changes in the character of the ore, particularly as regards soluble impurities, are always to be expected in large orebodies. The electrolytic process is very sensitive to changes thus brought about in the electrolyte. The installation and upkeep costs of the electrolytic precipitation process are very high and to obtain efficiency requires constant

supervision by high-priced men. One rather fundamental objection to electrolytic processes has not been discussed here to-night. In electrolytic processes, at least of the type which have been spoken of to-night, the copper content of the electrolyte can be reduced in the precipitation cells no lower than 1.5 per cent copper. That means that it is not easy to so conduct a cycle of leaching, precipitation, etc., that all of the water-soluble copper shall be removed from the ore and the volume of the solution in the cycle shall be kept constant.

"It is obvious that in any process in which there is practically complete precipitation of the copper, as in Weidlein's sulphur dioxide process, this washing difficulty does not arise. In place of losing soluble copper in the ore, one there loses a corresponding amount of sulphuric acid; and in Weidlein's process sufficient sulphuric acid is constantly being formed, so that this loss can be taken care of. As to the element of danger in processes in which a solution is heated under pressure, I would call your attention to the fact that there are thousands of boilers operating continuously in the United States under pressures considerably in excess of those used in the Weidlein process. We built in Nevada a 40-ton plant and we have had certain mechanical difficulties, as we expected to have. These difficulties we are meeting by the installation of a continuous process of precipitation. The advantages of continuous precipitation will be evident to all mill men. Our expectation that the cost of heat in this process of precipitating pure copper is less than the cost of electricity for electrical precipitation has been borne out. Of course, I recognize that there are localities where electrical power is so cheap that an electrolytic precipitation process should be the one to be considered, but I believe that for most localities in the western United States some of these other processes are more favorable as regards cost. In the Weidlein process, a very large excess of acid is constantly regenerated and all who have had experience in the leaching of ores know how desirable this is. In that connection I will say that we have developed a system of handling sulphur dioxide and a method of concentrating it from dilute flue gases. We believe we have made noteworthy progress in that direction, but I am not prepared at this time to go any further into that. In a short time we will be able to say a little more on the subject."

Mr. **Frederick J. Pope** described the experiments of A. W. Hahn and himself in controlling the effect of iron salts in solution. As between allowing them to remain in the electrolyte and there controlling their action, or removing them altogether, they decided on some process of removal.

"In considering how to remove iron from the electrolyte, we were reminded of the work which had been done by Hoffman at Argentine, where he precipitated iron from bluestone solution. Hoffman accomplished this by heating the solution in a suitable tank, agitating with air, and adding copper in an oxidized form. I think he used a roasted lead-copper matte. This work of Hoffman's gave us our idea for the removal of iron from the solution.

"For the copper oxide necessary in this work we have used high-grade copper carbonate ore, oxide formed by the roasting of cement copper, roasted high-grade sulphide ore, also roasted copper sulphide concentrates. In order to obtain a satisfactory reaction between the copper oxide and the iron, etc., in the solution, it is imperative to have the oxide material very finely divided. The roasted concentrates we used were ground in a small Abbé mill.

"From the Ajo carbonate ore we removed a little more than 2 lb. of iron per ton of ore treated. In order to keep the iron in the solution below the percentage deleterious to electrical efficiency, it was necessary to treat approximately one-quarter of the solution. We found that by manipulating the solution going on and off the ore in a certain way we could concentrate a large proportion of the iron in a certain part of the solution.

"In purifying, the solution was first heated to 195° to 200° F. When this temperature was attained agitation with air was begun and the finely ground oxide material was gradually added. Maintenance of a temperature of about 195° F. and agitation with air was continued for 3.5 hr. During the first hour all the ferric iron was precipitated. The removal of the ferrous iron was slower and we found that it was not advisable to endeavor to precipitate it all. In 3.5 hr. we easily precipitated 90 per cent of the total iron and at the same time removed 65 to 75 per cent of the alumina, 50 per cent of the manganese, and all of the arsenic, antimony, and bismuth which might be present.

"After the above operation the pulp was passed through a Schreiber wooden filter press. The solution came out beautifully clear and was sent to the high-acid electrolytic circulation system. We anticipated that with the precipitate produced we might have trouble with the filter cake; that it would be slimy and difficult to handle. We did not find it so. The cakes were 2 in. thick, firm, washed well, and the amount of copper in the form of unused oxide they contained was well within commercial limits.

"The only loss of acid is that entrained in the tailing, but this is easily counterbalanced by a proper control of roasting operations. Lead anodes were used, containing 4 per cent antimony, and the cost was estimated to be 0.2c. per ton of ore treated, with lead at 8c. per pound."

Mr. **J. Parke Channing.**—"The problem presented in the Miami district is a little different from that in the districts referred to in the discussion of this evening, inasmuch as the ore to be treated there is one which is a mixed chalcocite and carbonate. The gangue is particularly free from any impurities that go into solution, but the fact that both chalcocite and carbonate are present makes it a rather difficult problem. The particular ore deposit upon which we worked was that of the New Keystone, but the same class of ore existed in the Miami, and also on the Inspiration. The problem therefore presented to us was either a straight leaching one, which would have to be proceeded with by complete dead roasting, or else it would be a mixed process, water concentration followed by leaching, or possibly leaching followed by water concentration; and then finally, if flotation came in, we might have to make three bites of the cherry—that is, use water concentration, flotation, and leaching. You can readily see there would be a great many combinations and whether it would be desirable to leach first, then water concentrate, and then float, or whether it might be desirable to make the sequence different, we do not know. This Keystone ore averages about 2¼ per cent copper, of which anywhere from 30 to 40 per cent is oxidized. After making a number of concentration tests we decided upon attempting a dead roast; in other words, converting all to the copper into a soluble form and leaching it."

Mr. **R. C. Canby**—"The only thing I can think of which has not been mentioned is the circulation of the electrolyte. In our electrolytic work I designed the cells so that the solution, instead of flowing

lengthwise against the flat surfaces of the anodes and cathodes, flowed crosswise of the cell. In that way, in the use of sulphurous acid gas, I had hoped, by having a rapid circulation, to use a much smaller quantity of both copper and the depolarizing element in the electrolyte, with a correspondingly stronger current, and also to be able to precipitate the copper without heating the electrolyte. I was able to use a current density as high as 10 or 12 amperes per square foot with the temperature of the electrolyte about 18° to 20° C., and get a very satisfactory coherent deposit. I think that was the only novelty in the electrolytic work.

"The problem in roasting was to use our 14° Baumé fuel oil, to be burned at a temperature of 2000°, and yet keep our ore bed at not to exceed 800° to 1000° C. I accomplished this by using a furnace similar to that used for the Huntington and Heberlein process at El Paso, and at three other American smelting plants, the hearth revolving past the flame, so that I was able to roast the ore without at any time bringing the temperature of the roasting above the desired 1000° C., whereas the fuel was being burned at about 2000°, or a little over. The furnace was entirely of reinforced concrete construction and stood well."

Mr. Richard Lamb described his work in connection with a leaching and electrolytic copper plant at High Hill, Va., for the Virginia Copper Co., treating bornite and chalcocite ores. The ore contained 3 per cent copper, 1½ per cent sulphur, 89 per cent silica, 0.75 per cent lime, 1.5 per cent iron, 3 per cent magnesia and 0.35 per cent alumina. The ore was roasted in an Edwards furnace at a temperature of about 900° F. in order to convert iron to the form of sesquioxide, and leave the copper as oxide and sulphate. The roasted ore was treated in a leaching barrel with sulphurous acid of 10° Baumé for about 3 hr. The copper solution thus formed was filtered and electrolyzed, the sulphurous acid being changed to sulphuric. The voltage in each tank was 1.8, and a current density of 3 amperes per sq. ft. was used. The electrolyte was permitted to run from ¼ to ½ per cent copper when used for further leaching. The output was 30.6 lb. copper per hp.-day of 24 hours. With steam power costing $48 per hp.-year, the cost for electrolytic treatment was about ½c. per pound of copper produced. Total cost of producing copper was estimated at about 6.9c. per pound.

Discussion at Atlantic City

Mr. Lawrence Addicks, after having summed up the discussion which had been held in New York City, added some remarks of his own. Three essentially different problems should be distinguished. First, for sulphide ores roasting and leaching is now not very promising, on account of the tremendous quite recent developments in flotation. Second, for oxide ores, where conditions are favorable, leaching has come to stay. Third, mixed sulphides and oxides represent an entirely open problem and it is impossible to say which process will fit. The presence of silver and gold complicates the problem. As to precipitation, there is now an increasing tendency towards electrolysis. Scrap iron as precipitant is practically impossible, because there is not enough scrap iron available. Mr. Van Arsdale and the speaker found that carbon anodes can be used (which have heretofore been thought to be unsuitable in sulphate solutions); they used Acheson graphite electrodes. Compared with electrolytic copper refining, the bearing of all important factors is reversed in copper leaching.

While iron and aluminium had heretofore been considered the most detrimental impurities, they had now learned how to turn their presence to advantage and use the iron for depolarizer and let the aluminium sulphate grow and form a natural diaphragm which prevents the action of ferric sulphate on the copper cathodes. With a pressure of 0.7 to 0.8 volt they get 2 or 3 lb. per kw-hr.

Mr. G. W. Van Arsdale emphasized the two most important results of his leaching experiments: first, that graphite anodes can be used in sulphate solutions, and second, that it is possible to get along very well with foul solutions. Mr. Van Arsdale also discussed some interesting chemical reactions which they ran across in their experiments.

Mr. John V. N. Dorr showed in an interesting way how his well known machines, originally invented and designed for cyanide practice, are now being successfully used to solve certain mechanical problems in the three operations of copper leaching: dissolution; separation of dissolved copper from ore pulp, and precipitation.

Professors Frary and Richards also participated briefly in the discussion.

Friday Afternoon Session

After the discussion on copper leaching had been concluded Professor Frary presented his paper on the electrolytic production of magnesium.

Electrolytic Preparation of Magnesium

A paper by Professor Francis C. Frary and Harry C. Berman, of the University of Minnesota, gives an account of an experimental investigation undertaken to find the cause and cure of the difficulties met with in the electrolysis of molten magnesium potassium chloride. Early in their work the authors noticed that after electrolyzing magnesium potassium chloride for an hour in a large graphite crucible the electrolyte on cooling contained numerous dark spots. It was found that this was the suboxide of magnesium and the cause of its formation was further investigated with the following results.

Magnesium sub-oxide is formed during the electrolysis of magesium potassium chloride if magnesium oxide is present. A high temperature facilitates its formation. It is dark colored, heavier than either metallic magnesium or the double salt, decomposes water vigorously, is oxidized (if finely ground) in the air, and is apparently re-oxidized at the anode in the bath.

Magnesium sub-oxide cannot be formed by the reaction of magnesium (metal) on the oxide in the presence of the molten double salt at a bright red heat, and is apparently only formed under such conditions as exist in the electrolytic reduction of MgO.

Magnesium sub-oxide does not react upon a solution of anhydrous nickel chloride in absolute alcohol, while metallic magnesium does.

There is no evidence of the formation of a "metal fog" during the electrolysis, even at a bright red heat, and the dark appearance of the electrolyte under these conditions is due to the presence of the suboxide.

Magnesium oxide dissolved or suspended in molten magnesium potassium chloride does not react with dry hydrogen chloride, differing in this respect from lime. As the magnesium oxide cannot be removed from the electrolyte, its formation must be prevented during both the preparation of the electrolyte and the actual electrolysis.

Professor Frary's paper was discussed by Messrs. Lidbury, Richards, Taylor, Vorce and Bennett. Mr. Lidbury suggested that the black mass might have been something like a potassium-magnesium alloy and

refused to accept a new suboxide until it has been isolated and analyzed. Professor Frary summed up his reasons which led him to conclude that the lead mass cannot be anything else but magnesium suboxide.

Calorizing Metals

A paper by **Mr. W. E. Ruder,** of the Research Laboratory of the General Electric Company, Schenectady, N. Y., discussed the application of the "calorizing" process to various metals. The calorizing process consists in producing a rich aluminium alloy upon the surface of the metal to be protected and has already been the subject of a descriptive article in our vol. XII, page 730 (November, 1914).

The pieces which are to be calorized are packed in a mixture containing powdered aluminium. This mixture is made up of alumina and powdered aluminium with the addition of about 1 per cent of ammonium chloride. The aluminium varies from 5 per cent to 50 per cent by weight, depending upon the service to which the piece is to be put. For copper and brass parts the mixture is kept low in aluminium and the temperature of firing held at about 700° C.-800° C. For steel and iron, richer mixtures are used and the temperature of firing is increased to 900-950° C. These mixtures are used repeatedly with the addition of sufficient aluminium and ammonium chloride to make up for the loss at each firing.

Perhaps the most important application of this process is the treatment of iron to withstand high temperatures. While the pieces are kept at a high temperature, as in service, the originally narrow band of aluminium alloy on the surface widens as the aluminium diffuses into the iron.

This diffusion gradually lowers the amount of aluminium in the outside coating, especially if the piece be of heavy section. There is, however, a coating of Al_2O_3 all over the outside which still protects the pieces from oxidation, but if this is broken it cannot renew itself and deterioration sets in. This usually starts in spots.

This spotting, however, occurs only at temperatures above 1050 to 1100 deg. C. and may be prevented by using a small section so that the alloy when completely diffused still remains high in aluminium.

Calorized cast iron parts do not stand up quite as well at high temperatures as calorized wrought iron or steel parts, because of the large amount of gases they contain and also because of their tendency to swell. At 800-900° C., however, it stands up very well. Wires and thin ribbons can only be given a light coating if they are to be kept pliable, because the surface alloy is very brittle and unless very thin will check off.

This process is finding considerable application in furnace parts, pyrometer tubes, annealing boxes, combustion tubes, etc. The original dimensions are somewhat increased by calorizing, especially on the edges. On flat surfaces, however, there is only a very slight increase (0.002-0.004 inch = 0.05 to 0.1 mm.).

Copper parts are equally well protected by calorizing. The result in this case is to produce a coating of aluminium bronze very rich in aluminium. This coating protects the copper from oxidation right up to its melting point.

Nickel may also be calorized. Calorized nickel is particularly good to use in wire form because the coating, unlike that on iron, is not brittle. Thin ribbons for resistance furnaces, etc., when calorized remain quite pliable. Iron ribbon, on the other hand, becomes very brittle and must be shaped before calorizing or else shaped hot afterwards. Calorized nickel gauze is found to be very durable for combustion screens, etc.,

as it does not burn and remains pliable in heat.

In conclusion Mr. Ruder stated that calorizing protects metals from oxidation indefinitely at temperatures below 1000° C. Above this temperature it still increases the life of metal parts several fold. It is to be noted, however, that it forms no protection against ordinary atmospheric corrosion, except in the case of copper. The aluminium bronze formed in this case is also protective against corrosion.

The paper was discussed by Messrs. Addicks, Hinckley, FitzGerald, Mott, Richards and Vorce.

Fixation of Atmospheric Nitrogen

The conclusion of the Friday session formed a symposium on the fixation of atmospheric nitrogen. Two papers by Mr. Summers and Mr. Washburn respectively, were first presented which had already been read at a joint meeting of the New York section of the American Electrochemical Society and of the American Institute of Electrical Engineers.

The paper by **Mr. Leland L. Summers** giving a general review of the whole situation of fixation of atmospheric nitrogen, was abstracted at length in our April issue, page 241. At Atlantic City Mr. Summers himself gave an abstract of his paper.

The paper by **Mr. F. S. Washburn** on the cyanamide process is published in full in the present issue, page 309. At Atlantic City the paper was presented in abstract by Dr. Fink in the author's absence.

A "polemical note" on commercial nitrogen fixation, by Mr. **S. Peacock,** was then read. "The fertilizer industry of the United States uses annually somewhat more than 100,000 tons of combined nitrogen, computed as ammonia, and the annual increase averages about 8 per cent. The combined nitrogen recovered in the United States from the distillation of coal for various purposes may be stated as approximately 70,000 tons per year, with an annual increase of about 15 per cent; and this increase must be assumed to be practical for several years to come.

"As encouragement to commercial nitrogen fixation, it may be stated that many organic nitrogenous substances heretofore used in fertilizers are finding other and more remunerative uses; and with each year a stronger demand is made on sources of supply which must favorably affect nitrogen fixation. A serious limiting factor is the cost. To illustrate: to grow one bushel of wheat requires nearly four pounds of nitrogen, which at present prices on the farm somewhat exceed 60 cents in cost. It is evident that the cost is practically prohibitive.

"Agricultural nitrogen hunger has been a practical fact for generations, not because ample nitrogen could not be obtained, but because it cost too much. Practically, farmers resort to a form of nitrogen fixation by growing leguminous crops in rotation and otherwise, but unfortunately legume nitrogen is scarcely less costly than the commercial product. Commercially, the promblem is clear and explicit; either the price of farm products must be materially increased, or the cost of combined nitrogen must be lessened. The former may or may not indicate a confession of incompetency on the part of industrial chemists; it is the problem we have to consider.

"As a commercial undertaking, nitrogen fixation must remain substantially dormant so long as the ammonia produced as a by-product of coal distillation remains of such relative amount that it is capable of controlling the rewards of capital invested in nitrogen fixation. It may be accepted as a fact that no nitrogen fixation method has as yet been publicly proposed which can produce combined nitrogen as cheaply as coke by-product ammonia. However, many very prom-

ising processes have been suggested, and it is to be hoped that some one or more will prove successful. The paramount objective must be a producing cost at the factory not in excess of 4 cents per pound of ammonia; such process will lessen the cost of bread and greatly expand the consumption of fertilizer nitrogen.

"It is doubtful if any process simply effecting nitrogen fixation will attain the necessary efficiency; it is probably essential to work out a combination process which not only fixes nitrogen, but also accomplishes one or more additional useful reactions. An illustration of such process is the complementary formation of calcium carbonitride and phosphorus nitride, using a mixture of phosphate rock and carbon, with but one heat effect.

"With the low cost ammonia, oxidation processes will follow, solving the problem of cheap nitric nitrogen and such compounds as ammonium nitrate. The weak point of American industries generally is the enormous proportion of costs permitted to selling and distribution. Therefore, the concentration of associated values in final end products is an important factor. Thus, ammonium nitrate or ammonium phosphate are more economical than ammonium sulphate, calcium phosphate or sodium nitrate, as the latter carry constituents useless or worse than useless for industrial purposes.

"As the fertilizer industry must be regarded as the chief support of nitrogen fixation, the end products must be suitable for fertilizer needs. This implies a product constant in composition, soluble in water, not deliquescent, and one whose component parts do not readily assume undesirable forms, such as a gaseous or insoluble form. It is essential also that, when mixed with other fertilizer materials, such, for instance, as potassium salts, no reactions may occur tending to make the mixture hard and lumpy, or in any way lessen its dry granular state; otherwise the material cannot be used in distributing machines, and thereby becomes practically worthless.

"It may be assumed as a governing principle that a commercially successful nitrogen fixation process must give as an end product potassium nitrate, or ammonium nitrate, or primary ammonium phosphate; and, that the factory cost must not materially exceed 5 cents per pound of combined nitrogen figured as ammonia. It is true that the present price is several times that; but, having in mind the competitive power of by-product ammonia and the vast prospective increase in the production of same, capital is not justified in supporting a nitrogen project under other conditions.

"The host of synthetic ammonia processes, of which that of Dr. Haber is the best known example, can never become commercially important, though they may have a moderate local application.

"From the point of view of a somewhat intimate acquaintance with all the nitrogen fixation processes publicly known at this time, there is nothing in the above conclusions which should in the least discourage American technologists."

A very interesting and lively general discussion followed:

Mr. Summers would not agree with Mr. Washburn's claim that the cyanamid process was *the* solution of the atmospheric nitrogen fixation problem; on the contrary, he thought the tendency of nitrogen men in this country was toward direct combustion processes. He certainly did not think that the cyanamid process was the last word.

Dr. Bennett had sent communicated discussions both of Mr. Summers' and Mr. Washburn's paper. He thought no process was at present commercial and

that byproduct coke-oven ammonia would fix the cost of ammonia and determine the success or lack of success of fixation process. While the cyanamid process was the cheapest fixation process, yet ammonia from cyanamid could not compete with byproduct coke-oven ammonia.

Mr. Mott gave and discussed a mathematical equation for the efficiency of arc processes for nitrogen fixation.

Dr. Fink thought all processes should be encouraged. Dr. Richards said that the Cyanamid Company expected rapid developments in the whole field, with many changes from present practice in the near future.

Mr. J. E. Johnson, Jr., gave figures on byproduct coke-oven ammonia and suggested that in arc fixation processes an atmosphere enriched in oxygen should be used.

Mr. Summers agreed this would be theoretically better, but the dissociation which, on cooling, followed the formation of nitrogen oxides made the success illusory. It is not possible now to utilize fully the temperature of the arc, because the gas products are not quickly enough removed. There is phosphate rock in enormous quantities in this country. But the commercial trouble in this country is the expense of distribution methods; the distances are too great, or what amounts to the same thing, the freight rates are too high. Phosphate rock is sent to Europe and brought back in form of fertilizer. Of course, improvements will take place. Mr. Summers, in concluding, remarked that the Birkeland-Eyde process was the only process which had made nitric acid in Europe on a really large commercial scale and that the success of the Ostwald process, in conjunction with cyanamid, on a large scale, was still questionable.

Dr. Backeland spoke of the development of the fertilizer industry as a problem of opportunity. Belgium up to now has been using more nitrogen fertilizers than Germany and has produced yields greater than anywhere in Europe. But Belgium was compelled to do so; it was a process of gradual logical development. The rents for land in Belgium were very high (compared with this country), as the laws were made by the land owners. On the other hand the wages for farm workers (families with women and children) were low. Their salvation was the use of fertilizers and they used plenty of it to pay the landlord. As a result of the co-operation of Belgian farmers, fertilizers cannot be obtained anywhere in the world at as low a price as in Belgium. And this is the reason of Belgium's agricultural success; but the whole development took time. In time conditions in this country, favoring a greater use of fertilizers, will become more like those in Europe.

Professor Franklin referred to the spontaneous combination of oxygen with iron in presence of water, and thought that a nitride process based on the spontaneous combination of nitrogen with some metal in presence of liquid ammonia might be promising.

Dr. Whitney did not agree with Mr. Peacock's remarks on the Haber process.

The further discussion dealt largely with the question as to what will determine the price of ammonia. Besides byproduct coke-oven ammonia other sources of ammonia were discussed. The production of ammonia from Mond gas producers which, as Dr. Richards stated, is in successful operation in England, is not in use at all in this country. Dr. Baekeland called attention to peat as a source of ammonia.

Saturday Morning Session

On Saturday morning an early train was taken for Philadelphia, where the concluding sessions of the con-

vention were held at the University of Pennsylvania.

The morning session was held jointly with the Illuminating Engineering Society.

The first speaker, Dr. H. E. Ives, was introduced by the chairman, Mr. Addicks, as the personal representative of the fire-fly.

The Illuminating Engineer and Ideal Light

Dr. **Herbert E. Ives,** of the United Gas Improvement Co., Philadelphia, Pa., emphasized four important points in modern artificial illuminating practice:

(1) Lack of thorough understanding between the engineer who produces the light and the engineer who exploits this light.

(2) In spite of great improvements made in artificial illumination the intrinsic brilliancy of modern lamps is by far too intense for our eyes.

(3) The color of modern illuminants is very often not satisfactory.

(4) In the best modern illuminants the light obtained per unit power is strikingly low.

The distinctive function of the illuminating engineer is the utilization of light sources in the most efficient manner. Dr. Ives suggested that the illuminating engineer rewrite his specifications. He must tell the light producing engineer exactly what is required as a final product. Anyone can admire the dazzling intensity of the arc lamp, but it took a real student of the essentials of light production like Langley to realize that the common fire-fly is a much more wonderful light source.

Commenting upon the intrinsic brilliancy of modern light sources Dr. Ives pointed out that the tungsten vacuum filament is 300 times as bright as the brightest object by day, namely, a white surface in the sun. The nitrogen-filled tungsten lamp is 1000 times as bright and it becomes necessary to employ reflecting and diffusing media. What we require is a surface source of an intrinsic brilliancy of not over 1/1000 candle power per square centimeter. A true luminous paint which could be easily excited at will would meet this idea. A low intrinsic brilliancy is in great demand. What is really wanted is not a brilliant point, but a surface of low intrinsic brilliancy, like the surface of a window square.

The efficiencies of modern illuminants are surprisingly low. If we figure from coal 1 per cent is the best figure obtainable today. Light is actually only a small byproduct. The total luminous efficiency of a 4-watt carbon lamp is 0.42 per cent, that of the yellow flame arc 7 per cent. These figures are based on 50 cp per watt as the mechanical equivalent of light.

Flaming Arc Carbons

The paper on this subject by Dr. **William C. Moore,** which was then called up for discussion, has already been printed in full in our January issue (vol. 13, p. 52, 1915), since it had been originally presented before the New York Section of the Society.

The paper, which, in the absence of the author, had been read by Mr. Mott, was discussed at considerable length by Messrs. Barrows, Franklin, Hering, Darrah, Miller, Fink, Moon, and Richards. Dr. Fink suggested the possibilities of using flame-arc carbons in electric furnace work and Mr. Mott agreed that the flame-arc characteristics distinctly indicates such possibilities, as the voltage-current curve of the flaming arc starts at lower voltages and rises less steeply than the curve of the ordinary arc.

Lighting of Electrolytic Tank Rooms

A paper by Mr. **R. E. Harrington,** of the Edison Lamp Works, General Electric Co., Schenectady,

N. Y., discussed lighting of electrolytic tank rooms by means of tungsten lamps. Correct lighting increases safety and production, two factors of vital importance. This correct lighting may be secured by the proper selection of lamps and reflectors, the porcelain enamel reflector being given the preference. Of the various methods of lighting commonly employed the system of general illumination is most universally adaptable, although localized general lighting should be used where tanks are covered by hoods. Considering the question from a cost standpoint, experience has shown that in many cases the cost of proper lighting with the modern lamps is often less than improper lighting with the older types of lamps. In addition the advantages previously mentioned are obtained.

The paper was discussed by Messrs. Lidbury, Addicks, Stephens, Barrows, Franklin, Mott, Harrington, and Hogaboom. The question of the illumination of plating shops elicited quite an extended discussion of the best methods for producing artificial daylight for the correct matching of colors.

Saturday Afternoon Session

A complimentary luncheon at Houston Hall, tendered by the University of Pennsylvania to the Society and its friends, was greatly enjoyed. The afternoon session, held like the morning session at the Harrison Chemical Laboratory, was held jointly with the American Electroplaters' Society.

Electroanalysis

The session was introduced by an immensely interesting informal address of Dr. **Edgar F. Smith,** provost of the University of Pennsylvania. Dr. Smith said that it was for the fourth time that the American Electrochemical Society held a meeting at his laboratory and that there were good reasons why the society should feel at home in the congenial atmosphere of the University of Pennsylvania, where Robert Hare had worked on calcium to improve Davy's work and where Wolcott Gibbs had been a pupil of Robert Hare and had received the inspiration which led him to suggest the use of the mercury cathode in electroanalysis.

Dr. Smith then reviewed the very extended work of many years, carried out by him and his co-workers on electroanalysis. This sketch was as interesting in its chemical details as it was as a human document. He started his work on electroanalysis in 1878, but it took a long time to get converts. But by and by he and his case won out.

The latest achievement, described at the conclusion of the lecture, is a new method worked out by Dr. Smith and his assistant, Dr. Lukens, for the quantitative separation of cobalt and nickel. It is based on the observation that with a moderate current density nickel will not be precipitated from nickel ammonium fluoride, while the cobalt is precipitated. With a higher current density the nickel is precipitated as metal on the cathode and the cobalt as dioxide on the anode.

The lecture was illustrated by experiments, among which Dr. Lukens exhibited a simple method for agitating the electrolyte.

Cleaning and Plating in the Same Solution

A paper by Dr. **Oliver P. Watts,** of the University of Wisconsin, discussed the possibility of using the same solution for both preliminary cleaning and for plating proper. The author's experiments related especially to copper plating in connection with Lovering's solution, but some experiments were also made on brass plating and nickel plating.

The paper which, in the absence of the author, had been read by Professor Frary, was discussed by Messrs. Schluederberg, Addicks, Bennett, Hogaboom, Proctor, Benoliel and Frary.

Electrolytic Lead Deposits

A paper by Professor **Frank C. Mathers** and **Asa McKinney,** of Indiana University, points out that the electrolysis of solutions of lead nitrate ordinarily produces a mass of loose crystals upon the cathode. The authors have, however, succceeded in obtaining as smooth coherent lead deposits from lead nitrtate solutions as from any other lead bath.

The best composition of the bath is: 10 per cent lead nitrate, 2.5 to 5 per cent acetic acid and 1 per cent of the residue from the commercial extraction of Curacao aloes in the manufacture of aloin. Crude aloes may be used in the place of the aloes residue, but the deposits are not as good. The aloes or the residue should be dissolved by warming in the acetic acid before adding the lead nitrate solution. The bath should not be filtered before using. A current density of 0.4 amp. per sq. dec. (3.7 amp. per sq. ft.) may be used.

Free acetic acid is necessary in the bath to avoid the formation of basic salts. Free nitric acid in place of the free acetic acid greatly hastens the deterioration of the baths, and the greater the concentration of the acid the quicker the deterioration of the baths.

A number of addition agents were tried, but none approached the residue from Curacao aloes in efficacy. The aqueous extract of poplar wood, which gave excellent deposits in acetate baths, was not satisfactory in these nitrate solutions.

The baths have a life of only six or seven weeks, after which the deposits become spongy and non-arherent; consequently it seem unlikely that this nitrate bath can have any practical use. No way was found to overcome this deterioration of the baths.

A rough but not spongy deposit shows the exhaustion of some constituent of the bath. Warming the bath for a few minutes will bring more of the aloes residue into solution and correct any trouble due to lack of addition agent. Sometimes more acetic acid must be added to replace that which has been used in chemically dissolving the lead.

The paper which, in the absence of the author, had been read by Dr. Richards, was discussed by Messrs. Bancroft (who strongly suggested the application of broad fundamental principles to addition agent experiments), Lidbury, Bennett, and Addicks.

Electroplating with Cobalt

An elaborate paper, by Professor **Herbert T. Kalmus,** Mr. **C. H. Harper,** and Mr. **W. L. Lavell,** of Queen's University, described extended cobalt plating experiments made both in the laboratory and plating shops. The following general conclusions were reached from commercial tests:

Several cobalt solutions were found to be suitable for electroplating with cobalt under the conditions of commercial practice. Best among these are the following:

Solution I B:

Cobalt - ammonium sulphate, $CoSO_4.(NH_4)_2SO_4.$ $6H_2O$, 200 grams to the liter of water, which is equivalent of 145 grams of anhydrous cobalt-ammonium sulphate, $CoSO_4.(NH_4)_2SO_4$, to the liter of water. Sp. gr. = 1.053 at 15° C.

Solution XIII B:

Cobalt sulphate $CoSO_4$...........312 grams
Sodium chloride NaCl.......... 19.6   "

Boric acid.............nearly to saturation
Water ....1000 c.c.

Sp. Gr. = 1.25 at 15° C.

Cobalt plates from these solutions, on brass, iron, steel, copper, tin, German silver, lead and Britannia metal articles, of different shapes and sizes, deposited under conditions identical with those met with in general nickel plating practice, are firm, adherent, hard and uniform. They may readily be buffed to a satisfactorily finished surface, having a beautiful luster, which, although brilliantly white, possesses a slightly bluish cast.

The electrical conductivity of these solutions is considerably higher than that of the standard commercial nickel solutions, so that other things being equal, they may be operated at a lower voltage for a given speed of plating.

Solution 1 B is capable of cobalt plating on the various sizes and shapes of objects met with in commercial practice at a speed at least four times that of the fastest satisfactory nickel solutions.

Solution XIII B is capable of cobalt plating on the various sizes and shapes of objects met with in commercial practice at a speed at least fifteen times as great as that of the fastest satisfactory nickel solutions.

Plates from both of these solutions on various stock pieces satisfactorily withstood the various bending, hammering and burnishing tests to which commercial nickel work is ordinarily submitted.

These two very rapid cobalt solutions are remarkable for their satisfactory throwing power. That is, they readily and satisfactorily deposit the cobalt in the indentations of the work.

These two rapid solutions operate at these high speeds in a perfectly still solution without agitation of any kind.

These solutions are both cleaner, that is freer from creeping salts and precipitated matter, than the standard commercial nickel baths.

The cobalt deposited at this rapid speed is very much harder than the nickel deposited in any commercial nickel bath. Consequently a lesser weight of this hard cobalt deposit will offer the same protective coat as a greater weight of the softer nickel deposit. Considering solution XIII B, operating at 150 amperes per square foot, on automobile parts, brass stampings, etc., a sufficient weight of cobalt to stand the usual commercial tests, including buffing and finishing, is deposited in one minute. With the best nickel baths it takes one hour at about 10 amperes per square foot to deposit a plate equally satisfactory. Therefore, the actual weight of metal on the cobalt plate must be approximately one-quarter that of nickel.

For many purposes, under the condition of these rapid plating solutions, one-quarter the weight of cobalt, as compared with nickel, is required to do the same protective work. Consequently, if nickel is worth 50 cents a pound, in the anode form, cobalt could be worth nearly $2 a pound, in the same form, to be on the same basis, weight for weight of metal. In addition there are other advantages of cobalt in saving of labor, time, overhead, etc.

A smaller plating room would handle a given amount of work per day with cobalt than with nickel.

With these very rapid plating solutions, by the use of mechanical devices to handle the work, the time required for plating, as well as the labor costs, may be tremendously reduced. Solution I B, and particularly Solution XIII B, are so rapid as to be revolutionary in this respect.

Obviously the cost of supplies, repairs, etc., would

be less with cobalt-plating than with nickel-plating, as the size of the plant for a required amount of work is less.

The voltage required for extremely rapid cobalt plating is greater than that for most nickel-plating baths; it is not so great but that the machines at present in use may in general be operated. For the same speed of plating the cobalt solution requires much the lower voltage.

For a given amount of work the power consumption for this rapid cobalt work is less than that for nickel. This is obvious, because the total amount of metal deposited in the case of cobalt is very much less, whereas the voltage at which it is deposited is not correspondingly greater.

Ornamental work on brass, copper, tin or German silver would require only a one-minute deposit. Even wares exposed to severe atmospheric influences, or friction, could be admirably coated with cobalt in bath XIII B in 15 minutes. The tremendous possibilities of this solution are not to be completely realized unless mechanical devices are applied to reduce hand labor to a considerable extent.

Thick deposits from these solutions are vastly superior to any that we have seen produced from nickel solutions. The tendency to distort thin cathodes is less pronounced, while electrotypes and electro-dies have been given a superior thick deposit in a most satisfactory manner. The lines were hard, sharp and tough and the surface smooth. Nickel does not equal cobalt for excellence of massive plates.

Many of these tests were passed upon by uninterested skilled mechanics at the plant of the Russell Motor Car Company, who invariably reported in favor of the cobalt as above.

Both baths I B and XIII B are substantially self-sustaining once they are put into operating condition, and the amount of ageing required to do this is very much less for them than that for the present commercial nickel baths.

The paper which, in the absence of the authors, had been presented by Dr. W. Lash Miller, was discussed by Messrs. Bennett, Fink, Watts, Proctor, Hogaboom, Blum, Chapin, Lidbury, Lukins, and Richards. While most of the electroplaters present thought that cobalt plating could not become practical on a large scale until the price would be down to that of nickel, others expressed the opinion that if the electroplaters would go on with cobalt and create a demand the price would go down.

After a hearty vote of thanks the meeting adjourned. The next meeting will be held in San Francisco on September 16, 17, 18, 1915, and it is proposed to hold joint sessions with the American Institute of Mining Engineers and the American Institute of Electrical Engineers.

The following is an alphabetical list of those who registered at the meeting:

Mr. and Mrs. Lawrence Addicks, Douglas, Ariz.; Wm. H. Adolph, Philadelphia, Pa.; T. R. Alexander, Jr., Philadelphia, Pa.; Walter Arthur, Philadelphia, Pa.; L. H. Baekeland, Yonkers, N. Y.; Samuel Barr, Philadelphia, Pa.; G. S. Barrows, Philadelphia, Pa.; E. H. Bedell, New York City; Wm. J. Bell, Philadelphia, Pa.; S. D. Benoliel, Philadelphia, Pa.; E. Blough, Pittsburgh, Pa.; Wm. Blum, Washington, D. C.; Marston T. Bogart, New York City; A. F. Borbeck, Philadelphia, Pa.; P. A. Borek, New York City; Mr. and Mrs. de Courey Browne, New York; A. S. Callen, Philadelphia, Pa.; H. C. Chapin, Cleveland, O.; Mr. and Mrs. H. B. Coho, Mt. Vernon, N. Y.; Jacob Y. M. Connell, Darby, Pa.; V. F. Cooper, Buffalo, N. Y.; Wm. A. Cowan, New York City; S. F. Cox, Princeton, N. J.; Mr. and Mrs. J. S. Crider, Cleveland, Ohio; R. A. Crider, Cleveland, Ohio; T. E. Crossman, New York City; Mr. and Mrs. W. R. Cymor, Cleveland, Ohio; N. E. Dabolt, Mt. Vernon, N. Y.; C. Dittman, New York City; Jos. L. Dixon, Philadelphia, Pa.; John V. N. Doer, Denver, Colo.; John H. Dorricoth, Philadelphia, Pa.; Miss Emlen, East Orange, N. J.; G. S. Ettla, Philadelphia, Pa.; J. Wm. Fehnel, Bethlehem, Pa.; C. G. Fink, East Orange, N. J.; Mr. and Mrs. F. A. J. Fitz Gerald, Niagara Falls, N. Y.; H. S. Flanegan, Mt. Vernon, N. Y.; W. S. Franklin, Bethlehem, Pa.; Francis C. Frary, Minneapolis, Minn.; F. S. Fuller, Schenectady, N. Y.; A. E. Gibbs, Buckingham Que.; Miss Mabel E. Gibbs, Buckingham, Que.; Mrs. W. T. Gibbs, Bucking-

ham, Que.; H. W. Gillett, Ithaca, N. Y.; J. S. Glaze, Niagara Falls, N. Y.; Jac. S. Goldbaum, Norwood, Pa.; Jas. J. Guetz, Philadelphia, Pa.; R. E. Harrington, Newark, N. J.; August Heck, Philadelphia, Pa.; E. G. Henderson, Windsor, Ont.; Carl Hering, Philadelphia, Pa.; Edwin V. Hicks, Philadelphia, Pa.; J. Bennett Hill, Philadelphia, Pa.; A. G. Hinckley, Niagara Falls, N. Y.; H. K. Hitchcock, Pittsburgh, Pa.; Geo. B. Hogaboom, New Britain, Conn.; C. A. Holkesvig, Gibbsboro, N. J.; A. H. Hooker, Niagara Falls, N. Y.; Mr. and Mrs. W. F. Hubley, East Orange, N. J.; G. A. Hulett, Princeton, N. J.; O. Hutchins, Niagara Falls, N. Y.; Herbert E. Ives, Philadelphia, Pa.; J. E. Johnson, Jr., New York City; Roy Kegeneis, Philadelphia, Pa.; Mr. and Mrs. H. W. Kellogg, Niagara Falls, N. Y.; C. E. S. Kimer, Pittsburgh, Pa.; H. F. Kleinfeldt, New York City; Wilson Kutz, Philadelphia, Pa.; Edw. W. Lawler, Bayonne, N. J.; F. A. Lidbury, Niagara Falls, N. Y.; Charles F. Lindsay, Bridgeport, Conn.; Mr. and Mrs. L. M. Miller, Schenectady, N. Y.; W. Lash Miller, Toronto, Can.; H. S. Miner, Gloucester, N. J.; Wm. Roy Mott, Cleveland, Ohio; J. M. Muir, New York; John H. Müller, Philadelphia, Pa.; E. F. Northrup, Princeton, N. J.; N. Petinot, New York; Wm. Petinot, New York; Chas. H. Proctor, Arlington, N. J.; Jos. W. Richards, South Bethlehem, Pa.; E. G. Rippel, Buffalo, N. Y.; Howard S. Roberts (2nd), Philadelphia, Pa.; E. F. Roeber, New York City; F. W. Roller, New York; S. E. Ruder, Schenectady, N. Y.; L. E. Saunders, Niagara Falls, N. Y.; Carl G. Schlueder-berg, Pittsburgh, Pa.; Irvin Scioba, Philadelphia, Pa.; Mr. and Mrs. E. M. Sergeant, Niagara Falls, N. Y.; F. T. Setchfield, Salt Lake City, Utah; John M. Shrigley, Williamson School, Pa.; W. Acheson Smith, Niagara Falls, N. Y.; Walter F. Smith, Philadelphia, Pa.; W. M. Snow, La Salle, Ill.; L. L. Summers, Chicago, Ill.; O. R. Sweeney, Philadelphia, Pa.; Walter T. Taggart, Philadelphia, Pa.; Eben T. Takamine, New York City; Johich Takamine, New York City; H. S. Taylor, Princeton, N. J.; F. J. Tone, Niagara Falls, N. Y.; Phil. Uhl, Philadelphia, Pa.; G. D. Van Arsdale, New York City; Mr. and Mrs. L. D. Vorce, Detroit, Mich.; D. E. Weintraub, Lynn, Mass.; T. A. Witherspoon, Washington, D. C.; W. R. Whitney, Schenectady, N. Y.; Hiram S. Wilkins, Philadelphia, Pa.; A. M. Williamson, Niagara Falls, N. Y.; C. A. Winder, Niagara Falls, N. Y.; Chas. Wirt, Philadelphia, Pa.; F. C. Woodside, Pittsfield, Mass.; Mr. and Mrs. J. A. Yunck, South Orange, N. J.

Metallurgical and Chemical Engineering in Great Britain

(By Our London Correspondent)

The British Aniline Dye Industry
The Prospectus of British Dyes Limited

On March 6 the prospectus of British Dyes Ltd. was issued to the public. The authorized share capital is £2,000,000 debentures (for which public subscription was invited) and £1,500,000 4 per cent mortgage debentures to be advanced by the Government. The prospectus follows closely upon the lines of the Government announcement in the House of Commons on the subject, to which I referred to in my last letter. The following points only need mention: (a) the articles of association provide powers for the appointment of committees, including an advisory committee "of persons conversant with the science and practise of dying to advise the directors." (b) If the provisional agreements as to the acquisition of existing dye producing concerns are carried out, their present chemists and staff are to be retained as far as may be expedient. (c) Priority of supply of the company's product is reserved for shareholders subject to their signing a five years' agreement "to take their supplies from the company in all cases where the company is able to provide the same . . . of good quality and suitable for the consumers' business, and prices are reasonable." The dividends payable on the ordinary share capital are to be limited to 6 per cent until the debenture capital is extinguished. There are two Government nominees on the Board of Directors, Sir Frank Adams and Sir Gilbert Claughton. The remaining seven directors are representatives of the industry concerned.

British Dyes Limited—Its Critics

Naturally criticism has not been stinted, and it has been leveled from many points. On the one hand comes the demand for a protective tariff to foster the new industry. On the other hand doubts are raised as to our capabilities to develop the industry on an adequate scale in a worryingly brief space of time.

Still, when all is said and done the scheme is one of many which has received the best measure of support. Sir William Ramsay has come into the field with a criticism directed at the compositon of the board of

directors and speaks strongly on the absence of the scientific element on the board. To a very large extent this is inevitable. In a new industry of this character we have yet to evolve the equivalent of the kings of our iron and steel industry of the past like Sir Lowthian Bell or Sir Henry Bessemer, or to mention one name only, Sir Robert Hadfield, of to-day.

In far too many fields here we recruit commercial men and financiers for the boards of directors, and eschew the scientist and man of practical and technical experience. The result of this segregation has been woeful. The scientist and man of practical and technical experience is too often a child in matters financial and commercal. The financier, on the other hand, lacks to an even greater degree that technical knowledge and the scientifically imaginative foresight which has done so much in other countries. With all our inherent ingrained conservatism, one cannot but believe that the new type will be evolved and that speedily. A certain racial adaptiveness will be moulded by the forces making for industrial and economic evolution which will give us the new type. Not, of course, so quickly as we need or as we desire. The trend towards it has been evident for some time, and during which there has been a marked tendency to take the scientist from the microscope and the laboratory and give him control of works and processes and a voice in shaping the administrative and commercial policy of his firm. The critics came dangerously near to wrecking the whole scheme. Important sections of the industry held aloof. The subscriptions initially received were disappointing. A public meeting of subscribers was called and as a result sufficient blocks of shares were taken up to permit of the company proceeding to allotment. The matter is now on the knees of the gods. We must wait and see what follows.

Market Prices, March, 1915

	£	s.	d.
Aluminium ingots, ton lots	85	0	0
Alum, lump, loose, ton	£5, 5 & 5	10	0
Antimony, black sulphide powder, ton	45	0	0
Borax, Brit. refined crystal, cwt	20/ & 1	1	0
Copper sulphate, ton	29	0	0
Caustic soda, 70 per cent ton	10	2	6
Ebonite rod, lb	..	3	0
Hydrochloric acid, cwt	..	4	6
India-rubber, Para fine lb	..	2	5½
Mica in original cases, medium	..	3/ to 5	0
Quicksilver (Spanish), bottle	12	0	0
Sal-ammoniac, ton	49	0	0
Sulphate of ammonia, ton	14	0	0
Sulphur recovered, ton	8	0	0
Shellac, cwt	3	5	0
Platinum, oz., nominal	9	5	0
Zinc, cwt., sulphate	..	8	0

Copper opened £64.12.6 and fell away till the 3rd, £63.2.6. On the 4th it revived to £63.15.0 and continued stronger to £67 on the 20th. A temporary drop due to stoppage of exports then took place, but the price quickly recovered to £68.7.6 on the 22nd and £69 on the 24th, since easing a little to £68.5 on the 24th and closes £69.2.6.

Tin opened £183, fell off to £180 on the 3rd, and then rose till £190 was reached on the 9th, and the same price after a slight decline ruled on the 12th and 15th. The price then dropped, being £171.10 on the 22nd and £169 on the 24th, and touching £165.15 on the 26th. It recovered to £171 on the 29th and closes £171.5.0.

Haematite opened 82/6 and remained this price till the 17th, when it marked 85/- and rose to 87/6 on the 22nd. Settlement, 95/-.

Scotch Pig was 63/- on the 1st and rather weaker till the 5th, when it touched 62/10½, 63/6 being reached on the 8th, and prices then became stronger to 64/10½ on the 12th and 67/4½ on the 16th, culminating in 69/1½ on the 18th. There was then a temporary decline, but recovery was made on the 22nd, and 69/6 reached on the 24th. Settlement, 75/4½.

Cleveland opened 57/1½ and declined till the 3rd 56/6, it then improved till the 9th 58/-, and dropped on the 10th to 57/0½. Recovering, it reached 63/1½ on the 18th and after a slight dip resumed this price, rising subsequently to 65/- (26th) and 67/5 by the 30th and closes 67/3.

English Lead opened £20.15 and was £21 on the 5th and £24 on the 17th, at which price it remains steady and closes.

Synopsis of Recent Chemical and Metallurgical Literature

Gold and Silver

Recovery of Mercury from Amalgamation Residues of Cobalt-Silver Ores.—In the amalgamation of high-grade silver ores and concentrates in strong cyanide solution, as practiced in the Cobalt district, Ontario, Canada, considerable mercury remains in the residues and becomes a source of serious loss. A method of recovering this mercury has been devised by Mr. E. B. THORNHILL, of Cobalt, Ontario, and is in use at the Buffalo mill at Cobalt. In the April *Bulletin* of the Canadian Mining Institute Mr. Thornhill describes his process and gives some results of operation. His patent was reviewed in this journal, January, 1915, page 63.

After amalgamation mercury exists in the residues mainly as a mercuric sulphide and partly as elemental mercury. The process consists in leaching the mercuric sulphide from the residues by means of a caustic alkaline sulphide solution, and precipitating the mercury from solution by metallic aluminum. The reactions are thus represented:

$$HgS + Na_2S = HgS . Na_2S$$
$$3HGs . Na_2S + 8NaOH + 2Al = 3Hg + 6Na_2S + 2NaAlO_2 + 4H_2O$$
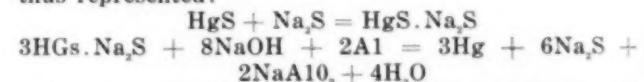
In operation, the residue in the pregnant cyanide solution is filtered on a Moore vacuum filter, and the cake thus formed is washed with water to remove silver solution. The filter basket is then immersed in a tank containing the sodium sulphide solution, and this solution is slowly drawn through the cake until the effluent shows only a trace of mercury. Usually one ton of solution is used per ton of residue. The filtrate is then agitated with metallic aluminum to precipitate mercury; the precipitate allowed to settle and the clear solution decanted. The precipitate is washed with water and dried, after which the fluid mercury is separated by raking the precipitate with a hoe. The remaining powdered material is retorted and the mercury condensed in the usual manner.

The strength of the solvent used in the filtering process is important. It has been found that a solution of 4 per cent sodium sulphide and 1 per cent sodium hydroxide gives best results. If weaker solution is used the quantity of solution must be proportionately increased, with the resulting necessity of handling the increased quantity of filtrate. Commercial sodium sulphide costs $1.25 per cwt. in barrels, f.o.b. Toronto.

The precipitant used is a waste product from aluminum casting foundries. It is 75 per cent pure, the impurities consisting of copper, silica, wood, waste, grease, etc. The grease is burned off before using the aluminum. About ¼ lb. of the metal is used per pound of mercury precipitated.

Sodium aluminate does not increase in solution, some is removed as hydroxide with the mercury, some as calcium aluminate on the filter cake. By this precipitation of aluminium, caustic soda is regenerated, so that the consumption of this substance is reduced to one-tenth of a pound per pound of mercury recovered. Sodium sulphide also is regenerated, but there is a

mechanical loss of about 20 per cent in leaching, as no wash water is used.

From May, 1914, to date, 37,650 lb. mercury has been recovered at a cost of about 13c. per pound for labor and chemicals. The mercury recovered is of exceptional purity, the only determinable impurity being silver in the quantity of about ¼ oz. silver per ton.

Cyaniding at the Bullfinch Proprietary, Western Australia.—In the monthly *Journal* of the Chamber of Mines of Western Australia, for December, 1914, and January, 1915, Messrs. A. L. HAY and R. B. WILLIAMSON give many details regarding the mill and operations of the Bullfinch Proprietary Company. The ore is a mixture of both oxidized and sulphide material in about equal proportions. The metallic minerals are gold, galena, pyrite, marcasite and pyrrhotite. The galena is silver-bearing. Some native silver occurs in the oxidized ore. A flow-sheet of operations is shown in the accompanying Fig. 1. In brief, the treatment consists in breaking in a Symons gyratory; crushing by
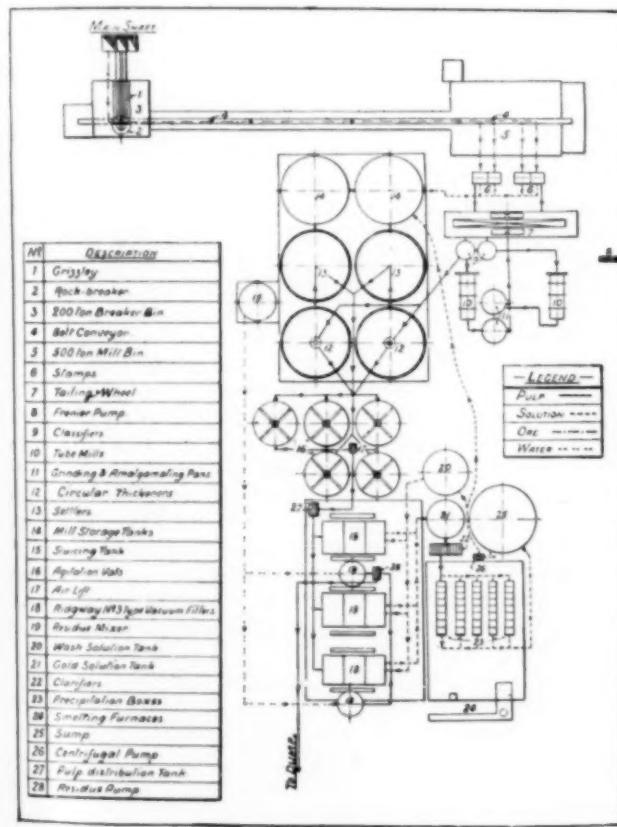

FIG. 1—FLOW-SHEET BULLFINCH PROPRIETARY MILL

1200-lb. stamps; hydraulic classification, with tube-milling of the oversize; pan-amalgamation of the tube-mill discharge; thickening and agitation of the classifier undersize; filtration by vacuum in a Ridgway filter; and precipitation in zinc boxes.

With stamps dropping 7 in. at the rate of 106 per minute, and crushing through 8-mesh screen on three batteries and a 4-mesh on one, the stamp duty is 11.06 tons in 24 hours. The grading is as follows:

Mesh	Per Cent
+ 10	5.55
+ 20	16.25
+ 40	14.80
+ 60	10.20
+ 80	3.35
+ 150	7.25
+ 200	2.95
— 200	39.65
	100.00

A 50-hp motor runs the batteries which consume 66

hp, the motor showing no difficulty in handling this overload.

A tailing-wheel elevates the crushed product to the hydraulic classifiers. The wheel is 40 ft. in diameter and has 112 buckets each of 720 cu. in. capacity. The peripheral speed of the wheel is 400 ft. per minute. Rope drive is used, and a manila rope 6 in. in circumference lasts 60 days. Power consumption is 7.3 hp, the wheel lifting about 2500 tons of ore and solution per day.

Tube mills are lined with corrugated chilled-iron liners which last 380 days. Plain end liners last 120 days. The tubes are belt-driven by a 40-hp motor; power consumption varies from 36 to 45 hp. Consumption of pebbles is 2.5 lb. per ton of ore crushed at the stamps. Following are gradings of tube-mill feed and discharge:

FEED TO TUBE MILLS		DISCHARGE FROM TUBE MILLS	
Mesh	Per Cent	Mesh	Per Cent
+ 20	15.15	+ 20	.10
+ 40	15.70	+ 40	.60
+ 60	20.85	+ 60	9.69
+ 150	37.35	+ 150	47.98
— 150	10.95	— 150	41.63
	100		100

During the above grading tests the tubes handled each 102 tons of sp. gr. 1.74. Power taken was 41.7 hp.

Amalgamation follows tube milling, being performed in grinding pans, the overflow of which is returned to the tailing wheel. Cast-iron shoes and dies are used, the former lasting three months and the latter six. About 150 lb. of mercury per month is added to the pans, and 31.2 per cent of the total value of the ore is recovered in this operation. Mercury loss is 0.005 lb. per ton of ore milled. Pans are cleaned up once a month. Power consumption for two pans is 12.5 hp.

The overflow from the conical classifiers is thickened to 1.5 sp. gr. This pulp is agitated in mechanical agitators, 18 ft. diameter and 8 ft. deep, made of ¼-in. steel plate The stirring arms make 10.5 r.p.m. Power required is 1.6 hp for each agitator. Cyanide is added at the agitators, and 5 lb. lead acetate per charge to precipitate soluble sulphides. Charges are 44 tons of pulp. Time of agitation is 10 hours. The agitated pulp is air-lifted to a tank feeding the loading vats of a Ridgway filter.

The filters are of the movable type, each having two vats, one for pulp and one for wash solution. Time of cycle of operations is:

	Min.	Sec.
Cake formation	20	0
Transport from pulp to wash tank	1	13
Washing	35	0
Transport from wash tank, discharging, thence to pulp tank	2	12
Total	58	25

Extraction is 93.34 per cent.

The five agitators, three filters, three vacuum pumps, residue pump and one 3-in. centrifugal pump are driven by a 70-hp motor by means of ropes. Average horsepower consumed is 38.

In precipitation the zinc consumption is 0.22 lb. per ton of ore, and 1.3 tons of solution is precipitated per ton of ore treated. Precipitation boxes are cleaned once a month; the precipitate is treated with acid. Consumption of sulphuric acid is 0.113 lb. per ton of ore treated. The gold-zinc slime is roasted in muffles, fluxed and melted. Bullion is 908 fine, of which 755 is gold, 133 silver, and the balance copper, lead, etc. Bullion from amalgamation is 715 fine in gold, 230 in silver and 55 base.

The cost of treating 37,976 tons of ore, including proportion of general expense and realization charges, is as follows:

Process	Cost per Ton	
	s.	d.
Rock breaking and conveying	0	4.21
Milling	1	10.58
Fine grinding and amalgamation	1	4.04
Settling and agitation	0	11.32
Filtration	0	11.2
Precipitation and smelting	0	4.49
Disposal of residue	1	3.05
Total	7	0.89

The cost of electrical power, including repairs and renewals:

Particulars	Cost per Hp per 24 Hours	
	s.	d.
Labor	0	5.49
Stores	0	10.92
Total	1	4.41

Water costs 7s. per 1,000 gallons, and firewood, chiefly salmon gum, morrel, and gimlet, costs 7s. 6d. per ton.

Concentration

Butchart Riffle System.—Fig. 2 shows the plan of a deck of a concentrating table of the Wilfley type fitted with riffles of the Butchart system developed at Morenci, Ariz. The riffles are the subject of a paper presented at the February, 1915, meeting of the A. I. M. E. at
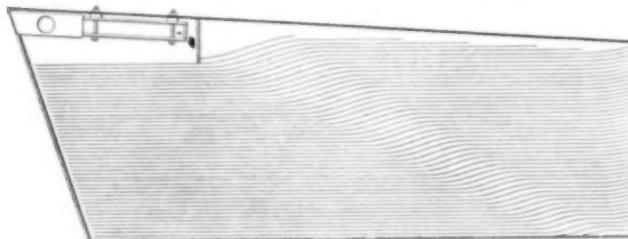

FIG. 2—BUTCHART SYSTEM OF RIFFLING

New York, by Mr. DAVID COLE. The following comparison of the old and new systems of riffling is made.

"The old system accomplished stratification satisfactorily but has insufficient means for separating the strata. The new system not only stratifies the minerals but is provided with ample means for segregating and separating them. The old system has a single cleaning channel, or zone, consisting of the diagonal depression adjacent to and parallel with the successively advancing ends of the riffles, and this is easily overloaded in a way to defeat in large measure the object desired. The new system has as many individual cleaning channels as there are riffles upon the table, and these are not easily overloaded because they are filled in succession and back each other up.

"The old system is not adapted to the handling of very coarse table feeds, stopping for good work at about 2½ mm size, while the new system handles very large tonnages of what have hitherto been jig sizes, with a much simpler arrangement of machinery and with greatly improved general results.

"The new system eliminates the necessity of hydraulic classification beyond the desliming stage. Desliming or classification of any kind is not required on coarse feed because the table rejection is usually dewatered and reground for future treatment, and when either primary or reground material is to be handled it is necessary only to remove thoroughly the slime either in spitzslutte or drag classifiers. When classification is carried further than this too much of the fine sand is eliminated, with detrimental effect upon the work of the new table.

"The new system requires less water than the old. The water consumption of the new system is from 250 to 275 gal. per ton of feed; therefore, when these tables displace jigs the water consumption is reduced from 50 to 75 per cent, and when used instead of the old system it is reduced approximately 50 per cent.

"With these advantages the new system is very important in wet concentration, particularly where the ratio of concentration to be practiced is medium or low, and when used in conjunction with a successful flotation treatment of colloid overflows it makes possible the construction of a most desirable wet concentrating plant, adapted to large tonnages in relatively small space, and for a minimum capital expenditure per ton treated."

Mr. Cole's paper also contains some results of operation, and analyzes in detail the method of operation of both old and new systems of riffling.

Chemical Engineering

Commercial Glucose.—In *Science Conspectus* of the Mass. Inst. of Techn. (Vol. V, 1915, No. 1) GEORGE W. ROLFE discusses commercial glucose and its uses, "a much misunderstood and maligned product, necessary for certain food staples and a good substitute for more expensive ingredients." The basic process by which commercial glucose is made, is on the lines of Kirchhoff's old experiment (boiling starch with dilute sulphuric acid and neutralizing with chalk), but the methods are quite different. The "starch milk," a suspension of the granules in water, is pumped into large pressure boilers of gun metal and is cooked for about ten minutes with a few tenths of a per cent of hydrochloric acid under a pressure of about 50 lb. of steam. In percentages of total sugars and dextrines, the product contains 45 per cent maltose, 20 dextrose, and 35 dextrin. This composition has been found to be the most desirable for imparting to the product the properties most suited for a syrup which can be refined readily, and at the same time contain enough colloidal material (dextrin) to prevent its crystallizing at any concentration. This colloidal matter also renders the syrup capable of dissolving considerable amounts of cane sugar without crystallization. The rest of the dissolved substance of commercial glucose consists of 0.3 to 0.5 per cent of mineral matter. There is also about 0.08 per cent of nitrogen corresponding to five or six times its weight of organic substances from the gluten left in the starch. The glucose process does not end with the acid treatment of the starch and the neutralizing, as at this stage the dilute syrup is far from pure, containing oily matters from the corn, some undecomposed gluten and other impurities mostly in suspension. This liquor before it is concentrated to a syrup of about 80 per cent solids, undergoes a refining with boneblack closely resembling that of cane sugar, the apparatus being practically identical—filtering through bags and boneblack filters—but in the case of glucose all impurities affecting the quality of the syrup have to be removed or destroyed as there is no purification by crystallization. The following table, taken from an advertising circular of a manufacturer, shows in a concise way how the different parts of the corn kernel are utilized.

Parts of Corn Kernel	Composition	Products
1—GERM	Oil and Oil Cake	Corn Oil, Corn Oil Cake, Corn Oil Meal.
2—ENDOSPERM (Body of the Corn)	Starch	Dry Starches, Dextrines, and by conversion, Corn Syrup [glucose] and Sugars
	Gluten	
3—HULL	Bran	Gluten Feed.
4—WATER ADDED FOR STEEPING	Soluble Substances of Corn	

The oil is used principally for soap and for making vulcanized products used for rubber substitute. The oil-cake and meal from the cake are used as cattle feed. The gluten and bran from the starch, mixed with the soluble matters extracted by the water used to soften ("steep") the grain before grinding is made into "gluten feed" also for cattle. All these are valuable by-products for which there is a good market. The

starch in a moist state, known as "mill starch," is the raw material for making the various goods which are sold under the names of "glucose" ("corn syrup"); "corn sugar" ("grape sugar"), the latter a hard product which is largely composed of dextrose, but never known in trade as "commercial glucose" and little used as a food product; "dextrins," true adhesives which are usually made by roasting starch and entirely different in characteristics from the dextrin ingredient of commercial glucose; besides numerous "dry starches" used by laundries, confectioners, and in many other industries as well as for household purposes.

Glucose is now used in a legitimate manner to mix with cane-sugar syrup in the proportion of 85 per cent of glucose to 15 per cent of syrup, a little salt and sometimes vanillin being added to improve the flavor. The cane-sugar syrup is usually refinery molasses ("barrel syrup"), which imparts the principal flavor. These mixed syrups are sold openly as glucose or "corn syrups." Commercial glucose is used in large quantities in the manufacture of cheap jams and preserves. Apple cores and skins from fruit in its preparation for evaporation or preserving are the basis for most cheap jellies; the pecten substance and juice being extracted by the usual processes of jelly making and mixed with glucose and sugar forms a jelly material to which other fruit juices are added. The law requires such jellies to be plainly described on the label. By far the largest amount of glucose is consumed in the manufacture of candy, the peculiar properties of this syrup making it especially valuable in this industry, as has been explained. The requisite for most candy is that it should not "grain" (crystallize), and glucose, owing to its colloidal nature, is the most effective and wholesome substance to prevent this. Glucose is extensively used in industries not making food products. It is used in cheap soaps, for "filling" leather and tanning extracts, and as many of its uses in such industries are apparently for adulteration such practices have no doubt added to its reputation as the "champion adulterant."

Powdered Coal Plant at Anaconda

The use of powdered coal as fuel, restricted for so many years to Portland cement practice, is now spreading rapidly in metallurgical, chemical and industrial works. A description of a typical and commercially successful powdered-coal plant should, therefore, be of timely interest.

In our March issue (pages 181 to 185) we gave an account of the two admirable papers, presented by Mr. David H. Browne and Mr. Louis V. Bender before the American Institute of Mining Engineers on coal-dust-fired reverberatories at Copper Cliff and Anaconda.

From Mr. Bender's paper we take the following description of the powdered-coal plant at Anaconda and have added some notes and illustrations of the principal apparatus used.

At Anaconda the equipment is larger than is required for one furnace, but was installed with the idea in mind of finally equipping the entire reverberatory plant for coal-dust firing.

"The coal from the storage bin is fed into a 30 x 30-in. Jeffrey single-roll coal crusher, where it is reduced to 1 in. maximum size.

"The coal is then taken by a belt conveyor to the foot of an elevator passing over a Ding magnetic pulley, which removes any pieces of iron, bolts, etc.

"The coal is then elevated and fed by gravity into a 40 ft. x 6 ft. Ruggles-Coles drier. The drier consists of two cylinders, the one within the other.

Blades of angle iron are fastened to the inner side of the outer cylinder and the outer side of the inner cylinder, so arranged that as the drier revolves the material fed into the space between the cylinders is lifted and dropped on to the inner cylinder and at the same time carried to the discharge end of the drier. The outer cylinder at the discharge end extends beyond the inner cylinder and has a revolving head riveted to it; on the inside of the head are buckets which lift the coal and deliver it out through the central casting. It takes a particle about 30 min. to pass from feed end to discharge end of the drier. At the feed end the inner cylinder is extended beyond the outer cylinder and, passing through a stationary head, is connected with the fire box.

"The gases are drawn from the fire box by means of a 72-in. Sturtevant fan, forward through the inner cylinder and back through the annular space between the cylinders to the stack. This exhaust fan is placed on top of the fire box and is connected to the drier by means of a 30-in. sheet-iron pipe. The fire box is fed with lump coal. The capacity of a drier depends upon the moisture in the coal and the speed of the fan. With Diamondville coal, we dry 18 tons per hour. During the month of September, 1914, we used 30 tons of coal to dry 1,984.77 tons of coal.

"From the drier the coal is elevated, conveyed by a screw conveyor, and discharged into a steel bin placed above the pulverizer, which is in a separate building from the drier. It is not well to have the pulverizer in the same building with the drier, for the reason that if an accident should occur, causing the coal to overflow, it might be drawn into the fire chamber of the drier and cause a fire, with possible injury to employees.

"The Raymond five-roller mill is used. It has an average hourly capacity of 4½ tons. At the top of the main shaft is a rigidly attached spider which rotates with the shaft and to the arm of which the five rollers are pivotally suspended by trunnions carried in bearings in the roller housing. Both upper and lower bearings of the roller journal are provided with long, removable, phosphor-bronze bushings. The rollers are made of cast iron with chilled faces. The grinding is accomplished by the force of centrifugal motion throwing the rollers outward against the steel bull ring. A plow is located ahead of each roller and constantly throws a stream of material between the face of the roller and the ring die.

"A fan is connected to this mill from which air is admitted underneath the grinding surface. The material is taken away by the air current as quickly as it is reduced by the rolls and blown into a 'cyclone dust collector' placed 20 ft. above the pulverizer. The mill is thus kept free of fine material. The collector is of galvanized steel, cone shaped, and has a return-air pipe leading from it to the housing around the base of the mill. A surplus-air pipe from this return-air pipe relieves the back pressure and is an outlet for any surplus air that may enter with the feed. An auxiliary collector is placed to receive the dust escaping through this surplus-air pipe.

"The finished product is discharged through a spout at the bottom of the dust collector, and is taken by a screw conveyor to a bin placed near to and above the furnace.

"The coal from the bin is introduced into the furnace by means of an air current delivered through five 'burners.' The air current is produced by a No. 11 Buffalo fan at a pressure of 10 oz., and, by means of a pipe carrying a nozzle, is introduced into a 6-in. pipe leading into the end of the furnace. The coal dust, fed from the bin by a screw conveyor, drops upon this

nozzle, which acts as a spreader, and is mixed with the air and taken into the furnace. A secondary air supply is obtained through the port holes through which the burners are projected into the furnace. These port holes are each 12 in. in diameter, which leaves an annular space 3 in. wide around each of the 6-in. pipes. By means of suitable dampers encircling the burners, this secondary air can be regulated. Another source of secondary air is through four openings between and above the burner ports, the size of the openings being regulated by putting in or taking out brick. The amount of coal fed is determined by the speed of the screw, which is easily regulated by a Reeves variable speed regulator. The entire grinding. conveying and bin system, from the drier to the burners, is air tight, as far as practicable, with the result that the entire plant is extremely clean and free from dust."

As to the excellent results obtained with this process of firing, the reader is referred to the further extracts from Mr. Bender's paper on page 184 of our March issue. In the present article we will give some further information on the apparatus used.

* * *

First, as to the **burners,** they are a special design gotten out by Mr. N. L. WARFORD of the Anaconda Copper Mining Co.

In Fig. 1, which shows the Warford pulverized-coal burner, A is the screw conveyor housing, B the mixing chamber housing, C the blast air nozzle, D the drive-
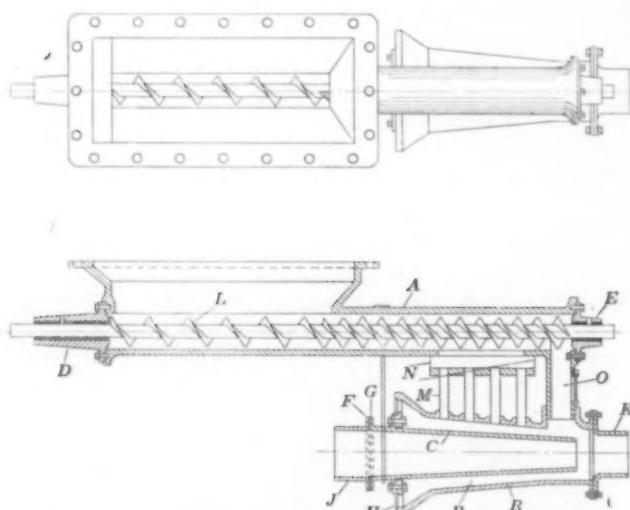

FIG. 1—WARFORD PULVERIZED COAL BURNER

end bearing of the conveyor, E the discharge-end bearing of the conveyor, F and G the blast-air control gate, H the free-air control valve or damper, J the sleeve to connect the blast-air pipe, K the sleeve to connect the discharge pipe to the furnace or fire box, L the screw-feed conveyor, and M connecting pipes between conveyor and mixing chamber.

The feeding device or control of quantity of coal dust required, consists of a screw conveyor enclosed in a dust-tight housing which is bolted to the bottom opening of the coal dust storage hopper, or bin through which the coal dust is fed into the screw by gravity. The screw carries the coal dust forward to the discharge end of the conveyor housing, where it is discharged into four receiving pipes, through a long narrow slot, and what does not go through the slot passes over and drops through a larger opening at the extreme end of conveyor housing.

The air and coal-dust mixing chamber consists of

an outer housing through which a blast-air nozzle extends. The coal dust as it drops from conveyor housing through the slot is drawn into and through the four pipes onto blast-air nozzle, and the coal that does not go through slot drops on end of air nozzle, through the larger opening at end of screw conveyor, and all of the coal dust entering the mixing chamber is drawn to end of blast-air nozzle and blown into furnace or fire-box.

The principal claims made for this burner design are as follows:

The slot in the bottom of the discharge end of housing A causes the coal dust to flow in a thin stream, onto pipes M. Free air is drawn in at N and mixed with the coal as it goes through the pipes M, and is drawn onto and around nozzle C.

By having the end opening larger than the other pipes, any clogging of screw conveyor is prevented.

The pipes M, arranged as shown in the sketch, cause

FIG. 2—ROLLER MILL WITH DUST COLLECTOR

the coal dust to get its first supply of free air as it is drawn through and the coal dust is broken up and mixed with this free air.

The free air damper or valve H, is so arranged that any amount of free air can be drawn into the mixing chamber P, up to its capacity.

The mixing chamber housing B, and blast-air nozzle C, are so arranged as to act as a siphon or injector, drawing in the free air, mixing it with the coal dust and injecting it into the furnace or fire-box, using pressure air as the power.

In general, the above claims assembled into one unit give the operator absolute control over both the coal dust and air, and thus enable him to secure thorough mixture of the air and coal dust, whereby a perfect

combustion of the coal dust in furnace or fire-box is obtained.

The Raymond five-roller mill and "cyclone" dust collector, which play quite an important part in the whole installation, are made by the Raymond Bros. Impact Pulverizer Co., of Chicago, Ill. (Fig. 2).

The mill consists of a number of perpendicularly suspended rolls, the capacity required determining the number of rolls, as the mill is built in sizes from two to five rolls. The rollers grind against a grinding ring; the material is thrown up between the roller and the ring by means of plows fastened to the slow-running central shaft, which only operates at a speed of about 115 revolutions per minute. In usual practice the speed of the mill pulley is about 240, with a system of gears of about two to one. The grinding is accomplished by centrifugal force, and as the rollers are free to swing towards the center of the mill, they will run over foreign matter, such as railroad spikes, without damage to the mill.

The mill will take coal crushed to pass a $1\frac{1}{2}$-in. ring and in one operation reduce it to any fineness required from 95 per cent passing a 100 mesh to 95 per cent or 99 per cent passing a 200 mesh.

The fan, which is located above the mill, automatically separates the finely pulverized coal from the coarse and delivers it into the "cyclone collector," from which

FIG. 3—FAN FOR POWDERED-FUEL INSTALLATION

the air is returned to the mill through the return air housing, so that the same air is used over and over again.

On account of the suction of the fan, the mill is dustless in operation, and on account of the air separation a finer and more uniform powdered coal can be obtained.

It is also possible with this system to grind coal with more moisture, if necessary, although the coal should be dried, as it is cheaper to dry the coal on account of the fact that to grind wet coal decreases the output of the mill or increases the horse-power for the same output.

On account of the air separation the coal is taken away from the mill as soon as it is reduced to the necessary fineness. This fact, together with air separation, keeps the temperature of the mill and of the pulverized coal down to the lowest possible point, for which reason it is possible to store the powdered coal in bins for a

longer time without danger of the coal taking fire from spontaneous combustion.

The Raymond mill with air separation will grind coal to any given fineness with about one-half the horse-power required for other systems and at the same time grind the finished product finer.

The Jeffrey single-roll coal crusher, which handles the coal coming from the storage bin, is built by the Jeffrey Manufacturing Company, of Columbus, Ohio. This is the type of coal crusher built by this company with a view to bigness, as the standard crusher of this type handles a 40-ton car of bituminous coal in 12 minutes, or more than three tons in a minute.

The drier used at Anaconda is built by the Ruggles-Coles Engineering Company, of New York City, and its construction is fully described in the excerpt from Mr. Bender's paper given above. The fan used in connection with the drier was built by the B. F. Sturtevant Company.

The No. 11 Buffalo fan, shown in Fig. 3, which is used for introducing the powdered coal into the furnace, is built by the Buffalo Forge Company, of Buffalo. It has a one-piece peripheral shell of heavy cast iron, to which side plates are fitted tightly and securely bolted. Either side plate may be readily removed, making it possible to take out the blast wheel when making repairs without entirely dismantling the machine. This fan is capable of delivering air against pressures as high as 18 oz. The one-piece peripheral shell does away with the putty joint, through which leakage is possible when the housing consists of two half shells bolted together along the peripheral line. The bearings are of the dust-proof oil-ring type, especially designed for high-speed service, the length being equal to over five diameters. An oil reservoir of large size is provided for the oil rings, making oiling necessary only at intervals of about once a month. The blast wheel consists of a heavy malleable iron hub with five arms upon which are mounted every alternate blade, there being ten blades in all.

Handling Condensation from Steam-Heating Plants

The Abbe Engineering Company, 220 Broadway, New York, have recently put on the market an automatic pump and receiver for handling the condensation from steam-heating plants. It includes a receiving tank with a special ball float inside of which operates the automatic electric switch. This automatically controls the operation of the pump. The float can be set to operate at any time: that is, it can be set to operate when the tank is half full, or three-quarters full of condensation. The pump returns the condensation to the boiler and it will pump against any pressure up to 30 lb.

The pump has its suction connected directly to the receiver into which the condensation from the heating plant flows by gravity, and the discharge from the pump connects to the boiler. This outfit is used in chemical plants, etc., to remove the condensation from any type of heating system.

The Abbe Engineering Company also has put a vacuum-heating pump on the market. This vacuum pump differs from the condensation pump inasmuch as this pump creates a vacuum in the heating system which allows the heating of largest buildings with about 1-lb. steam pressure, as the vacuum pump removes the air and condensation and returns condensation to boiler. With this latter system, vacuum valves are used on the radiators, and work automatically in connection with the vacuum pump.

Poidometer Test

The Schaffer Engineering & Equipment Company of Tiffin, Ohio, has just completed a series of tests on their poidometers for weighing and regulating the continuous flow of materials on conveyors, as described in our issue of March, 1914 (vol. 12, p. 206).

The test was made by marking the belt off in feet and placing an indicator so as to be able to get the exact travel of the belt. The machine was set to deliver 14 lb. of clay to the foot. A receptacle was placed under the delivery end of the machine and the machine was operated until it would run 6 ft. This would give 84 lb. of material. Each batch or the quantity on the 6 ft. was placed on a pair of very accurate scales and a careful record kept of each. Eighteen tests of this kind were taken. They produced 1517 lb. and should have produced 1512 lb., or, in other words, an accuracy of 99.67 per cent was obtained. The greatest variation between any tests was $\frac{1}{2}$ of 1 per cent.

Fire clay was used in making this test, which was more or less sticky and was prepared so that part of it was fine material and part of it was very lumpy, some of the lumps being as large as 2 in. in size. The material was separated and fed into the machine in a divided manner, so as to produce as large a variation in the condition of the material as possible. By cubical test the material showed that it would vary in weight 20 per cent in accordance with its volume.

One test was made by using plaster containing hair, without any changes being made on the machine from its adjustment for running the clay, and a 99 per cent accuracy was obtained. It will, of course, be understood that this was about a 100 per cent change in the volume of the two materials. One test was made with 1 in. crushed limestone and an accuracy of $99\frac{1}{4}$ per cent was obtained without any adjustment being made on the machine.

Electric Steel Refining

The Snyder Electric Furnace Company, 53 West Jackson Boulevard, Chicago, is just completing the installation of a second 3-ton furnace for the Otis Elevator Company, Buffalo, N. Y. This furnace will have a basic lining, and will be used in the manufacture of refined steel castings. The contract for this second furnace was closed nine months after the first one was put in operation. It is expected that the new furnace will be running about the middle of April.

The Snyder Electric Furnace Company is also installing a small furnace for the Niagara Electric Steel Corporation, at North Tonawanda, N. Y. This furnace will be lined basic, and will have a daily output of 6 tons of refined steel.

In addition to these two furnaces, the Snyder company is just completing the installation of three different electric furnaces to be used in special chemical work. These will be in operation within the next few weeks.

The same company has recently issued a nicely illustrated pamphlet, entitled "A Better Steel at a Cost Lower Than Open Hearth for Equal Tonnages." The claim is made that the Snyder furnace produces steel of a quality better than crucible steel at a cost below that of an open-hearth furnace of equal capacity. To substantiate this claim, efficiency calculations are made. It is found that a combined gas producer and open-hearth installation has an efficiency of 7.8 per cent, while a combined gas-producer, gas-engine and Snyder electric-furnace installation has an efficiency of 8.6 per cent. The thermal efficiency of the Snyder electric furnace alone is stated to be a trifle better than 70 per cent. Reliable simplicity is claimed for the Snyder furnace

design, which is single-phase with a single electrode at the top. "Snyder 3-ton furnaces in regular daily operation are showing melting costs considerably under $20 per ton for metal in the ladle. One of these furnaces, in operation over a year, has in eight months' time only missed one heat, which it theoretically should have poured. This furnace runs only at night, using electricity purchased from the local power company on an off-peak schedule. The power is turned on at 7 p. m. and shut off at 6 a. m. During this eleven-hour period each night, four heats are made, melting from cold material. Occasionally five have been melted in the same length of time.

"With current at $\frac{3}{4}$ cent per kilowatt-hour, using a Snyder 6-ton unit, capable of producing ten heats in twenty-four hours, it is entirely practical to put steel into the ladle at a conversion cost equal to the usual records made with 50-ton open-hearth furnaces. This includes all items for labor, electricity, upkeep and repairs, and all fixed charges."

An Improved Diaphragm Material— Electro-Filtros

BY C. J. THATCHER

The lack of a satisfactory diaphragm material has probably hindered or prevented the commercial success of many promising electrolytic processes. At first thought it might seem that there should be no difficulty in obtaining cheap, porous or semi-permeable materials, suitable for prolonged commercial use as a diaphragm in any given electrolyte. Experience, or at least that of the writer, has not warranted any such optimistic view of the matter.

The readers of this journal need only be reminded of what the properties of a diaphragm material should be A diaphragm should be moistened by, but not be permeable to liquids except by diffusion, so that the anolyte and catholyte, or suspended solid constituents therein, will not commingle during considerable periods. A diaphragm is generally used to prevent such commingling of the anolyte and catholyte. For this reason a diaphragm material should either not be porous, or should have such exceedingly fine pores as to offer a high resistance to the passage of liquids therethrough.

But, on the other hand, a diaphragm material should offer little resistance to diffusion or migration of ions, so that the electrical resistance will not be so great as to be prohibitory. This requires that the diaphragm material should be somewhat porous.

These two fundamental considerations limit the range of materials suitable for diaphragms to those which are somewhat, but not very porous. But this is not all that a diaphragm should be. For commercial use it should be strong, of course, so as to stand the wear and tear of factory operations; and it should be permanent, that is, not disintegrated by the electrolytes or products of the electrolysis. If the material is not strong or permanent it should be very cheap, easily replaced, and readily obtainable in all shapes and sizes.

A moment's reflection shows that few, if any, available materials have possessed all of these requisite characteristics, and that the ideal diaphragm material for commercial purposes has not been obtainable. Porous earthenware or porcelain—the so-called Pukal ware— has perhaps approached nearest to the ideal of what diaphragm materials should be. Porous cups, with which all are familiar, are generally satisfactory for laboratory purposes, but not for large scale operations; for they are not cheap and are not available in commercially useful sizes and shapes. The writer at one time sought far and wide in this country, but without suc-

cess, to locate some concern which had, or could manufacture, suitably porous cups holding a gallon or more, or suitably porous earthenware plates 12 by 12 inches square or larger. Perhaps such materials are available abroad; they are certainly not in this country, particularly at the present time when many want them.

Other materials which have been used for diaphragms are paper, parchment and membranes; but these are not strong nor permanent enough for successful factory use in most electrolytes. Asbestos cloth is too porous, and often disintegrates rapidly. Wood can be used in a few cases, as it is in storage batteries, but not in strongly corrosive electrolytes, nor is it very effective as a separator of anolyte and catholyte liquids. There may be other materials which have been found satisfactory in isolated cases, but which the fortunate user has not been anxious to proclaim.

It may be safely said that in most instances the inventor or engineer who seeks to install, on a factory scale, electrochemical processes requiring efficient diaphragms, meets with a serious and often insurmountable problem when he casts about to secure a material suitable for his diaphragm.

Under these circumstances it is gratifying to be able to state that a material which appears to be highly satisfactory for most diaphragm purposes has been produced in this country. This new material is called "electro-filtros" and is being manufactured by the General Filtration Company of Rochester, N. Y. The writer has been using this material in small-scale factory operations for about three months under very severe conditions and feels justified in stating that it is not attacked or altered by dilute or strong acids, and that it has a permanent, low resistance but at the same time effectively and permanently prevents mixing of anolyte and catholyte liquids.

This materials is constructed of grains of finely pulverized, pure, crystalline silica, which are cemented together with a small percentage of a fused, silicious bonding substance by a process which has been patented. During the preparation of the material it is subjected to various treatments for which patent rights are also being obtained. The finished diaphragm material is white or nearly so, strong and rigid, of remarkable uniformity and resistance to acids, weak alkalies and neutral solutions. Electrochemists will perhaps be mainly interested in its strength, permanence, electrical resistance and effectiveness as a separator of anolyte and catholyte liquids.

As regards the strength of the diaphragm, it may be stated that it will stand any mechanical stresses to which it may be subjected. It will not crack nor break with a pressure of 90 pounds per square inch. A cross bend test shows that a plate 12 by 12 by 1½ inches, supported on ½-inch bearings, is capable of sustaining a load of 400 pounds applied to the middle.

In passing it may be stated that the material can be made of almost any thickness from ¼ inch up, but that it usually comes in plates ½ to 1 inch thick and which may be as large as 16 inches in one dimension. The standard shape is 12 by 12 inches, but of course the plates may be made larger or smaller as desired. It can also be made into tubes and cylinders of reasonable dimensions for exceptional processes or devices of special design. Large diaphragms can be constructed by fitting suitably sized plates in a supporting framework of suitable materials, and in which the plates may be cemented with sulphur, paraffin, retort cement, or other appropriate substances.

In the matter of permanence, electro-filtros leaves little to be desired, at least as far as use in acid and neutral electrolytes is concerned. It is not affected by any organic compound nor by any of the acids (excepting

hydrofluoric) or their salts. The material is attacked by hot concentrated alkalies, but not by weak alkaline solutions, particularly at low temperatures. The electro-filtros plates which the writer has been using for nearly three months, in both dilute and concentrated acids at low and high temperatures, have not changed whatsoever during this time, as regards either their strength, permeability or electrical resistance.

The electrical resistance of this material depends largely, of course, on the electrolyte, but it is constant with any given electrolyte under constant conditions. As an illustration it may be stated that measurements recently made in an electrolyte consisting of about 60 per cent sulphuric acid and using, as the diaphragm, 12 by 12 inch plates, ¾ inch thick, which have been in continuous use during the past three months, gave the following results:

With the electrodes close against the diaphragm, i.e., about ¾ of an inch apart, and a voltage drop of 5.6 volts between the poles, a current of 33 amperes flowed through the diaphragm. With the same electrodes, placed the same distance apart as before, and in the same electrolyte, but without the interposition of the diaphragm between the electrodes, a voltage drop of 5 volts gave a current of 43 amperes. That is, under the same conditions the resistance per square foot through the diaphragm was about .17 ohms, as compared with a resistance of .115 ohms through a volume of the electrolyte of the same dimensions as the diaphragm. In other words, the resistance through the diaphragm was less than twice as great as that of the sulphuric acid used as the electrolyte. This is practically the relative resistance which the same diaphragm showed when it was first used about three months ago.

Tests with other plates and in other electrolytes have sometimes given a higher relative resistance, amounting in one instance to as much as 3½ times that of the electrolyte; but the resistance has remained constant throughout the period of the test. For convenience most of these latter tests have been made with smaller electro-filtros plates, 3 by 3 by ½ inch dimensions.

With plates of this size, using, in one instance, concentrated zinc sulphate containing about 1 per cent sulphuric acid as the anolyte, and 20 per cent sulphuric acid as the catholyte, and with lead electrodes about 1¼ inches apart, a voltage between drop of 3.5 volts across the poles gave a current of .44 amperes at 12.43 P. M. and of .46 amperes at 5.49 P. M. The electrolysis had been continued during the intervening five hours, during which time the voltage remained constant. This gives a combined resistance through the electrolytes and diaphragm of about 7.6 ohms, for a 3-inch square plate ½ inch thick, which figures to 0.125 ohms per square foot. This same 3-inch square diaphragm was subsequently used for many hours as a separator between the above specified zinc sulphate and sulphuric acid electrolytes, without noticeable change in the electrical resistance through the diaphragm.

Since the anolyte and catholyte in this test were not of the same composition it was impossible to make a comparative test of the relative conductivities with and without the separator, such as that made, as above described, with the larger plate. But a similar, subsequent determination of the relative resistance of this small, 3-inch plate, when used as a diaphragm in dilute sulphuric acid, showed that the resistance through the diaphragm was 2 ohms. Through the same dilute sulphuric acid electrolyte, without the plate, the resistance was 1.26 ohms.

So that the resistance through the diaphragm with a given electrolyte was again less than twice that of the resistance of a body of the same electrolyte of the same dimensions as the diaphragm; and even after this dia-

phragm had been used for many hours as a separator in electrolytes containing a metal salt.

The behavior of this diaphragm material in weak alkaline solutions was determined by the following tests: A small 3-inch square diaphragm was placed in an electrolytic cell, both compartments of which were filled with about 20 per cent sodium hydrate solution. After standing for 24 hours the resistances through the diaphragm and through the volume of the electrolyte of the same dimensions as the diaphragm were determined as above described. The resistance through the diaphragm was found to be 3 ohms, and that through the same sodium hydrate electrolyte, without the diaphragm, 1.3 ohms. The permeability of the plate did not change during the period before specified. Tests showed that the caustic soda solution could be forced to percolate through the plate only very slowly, even under considerable pressure.

The foregoing figures show that the increase in the resistance of an electrolytic cell in which electro-filtros is used as a diaphragm is remarkably low. In electrolytic cells in which the electrodes are placed any considerable distance apart, or in which the electrolytes themselves have any considerable resistance, the increase in the resistance occasioned by the use of electro-filtros as a diaphragm is practically negligible.

For example, in any large electrolytic cell in which the electrodes are, say, 12 inches apart, and in which the total internal resistance of the cell is, say, 0.5 ohms, or $0.5 \div 12 = 0.04$ ohms per linear inch of the electrolyte between the poles, then the interposition of an electro-filtros diaphragm one inch thick between the electrodes would increase the resistance about $0.04 \times 2 = 0.08$ ohms. So that the total resistance between the electrodes, using the diaphragm, would be 0.58 ohms as compared with 0.50 ohms without the diaphragm, and the increased resistance due to the diaphragm would be practically negligible.

That electro-filtros diaphragms offer such a negligible resistance to the passage of the electric current is the more remarkable when viewed in connection with the impermeability of the material and its effectiveness as a separator between electrolytes of different compositions.

The following facts illustrate the impermeability of this diaphragm material, and show how far it prevents mixing of anolytes and catholytes.

One compartment of an electrolytic cell, provided with the 12 by 12 inch electro-filtros diaphragms which have been continuously used for the past three months, was filled recently with dilute sulphuric acid, the other compartment being empty at the start of the test. Since the diaphragm was placed vertically in the cell and the compartment at one side was filled with the dilute acid, there was a head of about 12 inches. The compartment filled with the dilute acid at the start of the test was about 12 by 5½ inches, and of course 12 inches deep. During the course of an hour the level of the acid fell ⅝ of an inch. Neglecting the leaking around the cemented edges (which was considerable), this indicates that only about 600 c.c. of acid could be forced to percolate through the diaphragm with a pressure of 12 inches of dilute acid in one hour. In a similar test of another diaphragm which had also been in continuous use for three months 650 c.c. of dilute acid was forced through the plate in one hour.

All who have had experience with the high rate of flow of liquids through diaphragm materials which have hitherto been available, will appreciate the advantage of a diaphragm material such as electro-filtros, which so effectively resists the passage of liquids through its interior, and at the same time possesses such a low electrical resistance as is shown by the tests previously described. Other tests, which it is unnecessary to describe in detail, show that this new diaphragm material has and retains the same impermeability to other electrolytes, both acid and alkaline, and neutral salt solutions.

These tests, it is believed, establish that electro-filtros is a permanent and effective diaphragm material; that it is not a filtering medium as are most diaphragm materials. This material is permeable, practically, only to diffusing liquids or migrating ions, which accounts for its low resistance to the passage of the electric current and its effectiveness in preventing commingling of the constituents of anolyte and catholyte liquors.

New Cupels

The Joseph Dixon Crucible Company, Jersey City, N. J., have put on the market what they term "Dixon's wonder cupels" for the use of refiners and assayers.

These are made in three sizes, 1¼ in., 1½ in. and 1¾ in. in diameter. They are not only strong and handable, but the absorption of silver into the cupel is much less than with cupels made from bone ash when used under similar conditions. They are made of such strength that they will not break in handling, and, in fact, meet exactly the requirements of the assayer.

The foreign manufacturing districts where clay and sand crucibles are made are in so deplorable a state at present that it has been a question for some time past if it would be possible for them to fill the demand of the laboratories and refineries of this country. The Joseph Dixon Crucible Company have now entered the field of assay crucibles, scorifiers and goods of a like nature, so that at present they have a fairly complete line of this class of goods. So far the sale has not been of so great a volume that they have been able to compete in price with foreign makers, but as scarcity increases and larger orders are secured there is little doubt but that as low, or possibly lower, prices can be made than imported goods of a similar nature now sell at.

The Schaeffer & Budenberg Mfg. Co., of Brooklyn, N. Y., has completed occupation of their new plant at Berry and South Fifth streets, near the Bridge Plaza (Williamsburg Bridge) in Brooklyn. The new building is a seven-floor reinforced-concrete structure with 10,000 square feet floor space to the floor. The company was founded in 1850 and has manufacturing plants in all parts of the world; one of their European factories has upward of 5000 employees. The Brooklyn firm was established in 1878. The products of the company are a complete line of thermometers, gauges, recording gauges, recording thermometers, counters, time recorders, indicating and recording tachometers, electric pyrometers, steam, oil and gas engine indicators, steam calorimeters, gauge testers and other instruments. One-half of an entire floor in the new main office is used as an exhibition room and equipped with a representative and complete line of the many instruments and testing apparatus made by the concern.

The C. & G. Cooper Company, of Mt. Vernon, Ohio, has issued Bulletin 54 on Cooper gas engines. It contains brief and well illustrated descriptions of some important gas engine installations recently made in this country. Among them are three 27½ in. x 42 in. twin tandem double-acting Cooper gas engines, direct driving low and high-pressure gas compressors, at the Taft, Cal., station of the Southern California Gas Company. These units deliver 30,500,000 cubic feet of free gas in 24 hours against a delivery pressure of 450 lbs.

What the Panama-Pacific International Exposition Means to the Metallurgical and Chemical Engineer

To be "educational" is the primary purpose of the Panama-Pacific International Exposition, and in the department of mines and metallurgy this motif is perhaps even more evident than elsewhere in the main palaces. It has been said that anyone engaged in or interested in mining and metallurgical work cannot visit the department devoted to these subjects without learning much that is of value. The general public, the young student contemplating his chosen profession, and the expert metallurgist backed by a lifetime's experience, were all planned for by those who arranged the

FIG. 1—EASTERN FACADE, PALACE OF MINES AND METALLURGY

features of the Palace of Mines and Metallurgy and exemplified therein "the natural mineral resources (metallic, non-metallic and fuels) of the world; their exploration and exploitation; their conversion into metal; their manufacture into structural forms and into raw materials for various industries."

Prof. Charles E. van Barneveld, chief of the department of mines and metallurgy, has announced it as his aim to illustrate within the palace devoted to these industries every mineral of economic importance, not merely by mineralogical and geological specimens, but by complete industrial exhibits, which begin with the undeveloped mineral resource, end with the article sold to the retail trade, and show, insofar as possible, the intermediate processes of mining, reduction and manufacture. Especial attention has been given to copper, lead and zinc, while the iron and steel industry is shown by a series of exhibits which Professor van Barneveld pronounces the most complete ever assembled.

The Palace of Mines and Metallurgy is located at the northeast corner of the main group of exhibit palaces facing on the Marina and lying between the Court of Abundance and the Avenue of Progress. The structure itself is rectangular in plan and covers an area of about 6 acres. At its center the roof curves upward into a dome 165 ft. in height and 130 ft. in diameter. Perhaps the most unique feature in arrangement is the idea of supplementing the area available for exhibits by utilizing space underground. A large area was excavated beneath the floor for a complete demonstration mine, where full-sized entries, drifts, stopes and rooms are shown with actual coal and ore faces in place, thus permitting the demonstration of various drilling, con-

veying, ventilating, pumping, and other equipment.

Throughout all the departments of the exposition a twofold object has been kept in view in the selection and arrangement of exhibits: first, to make the displays contemporaneous rather than historical, and second, to have machines in motion where possible, or to show processes by stages if feasible, so as to facilitate quickly acquiring a comprehensive idea of that which is presented. However, in the Palace of Mines and Metallurgy it has been made possible to go even farther than this. Hardly to be classed as an ordinary "moving exhibit" is the daily explosion which actually occurs in the mine beneath the Palace, followed by the hurried arrival of the mine-rescue and first-aid motor car, the testing of helmets in the foul gas within a glass smoke-room, and then the resuscitation of "victims" actually brought up from below. Ranking still higher in educational value is the experimental work constantly going on in the Government metallurgical laboratory established within the Palace in connection with an open metallurgical forum, which is expected to be a rendezvous for technical experts from all parts of the world.

The laboratory is something of a new departure as an exhibit in that original research is actually being conducted here at the same time that its arrangement and equipment is a display in itself. It is admitted that some interference may be occasioned by giving free access to the laboratory to all who may be interested in the work in hand, but from the number of experts who are expected to spend some time there during the exposition it is believed that the gain from their interest and suggestion will outweigh any hindrance that there may be. The model laboratory and the work under way there is in direct charge of Dr. F. G. Cottrell, chief physical chemist of the United States Bureau of Mines.

A schedule of research work actually being carried
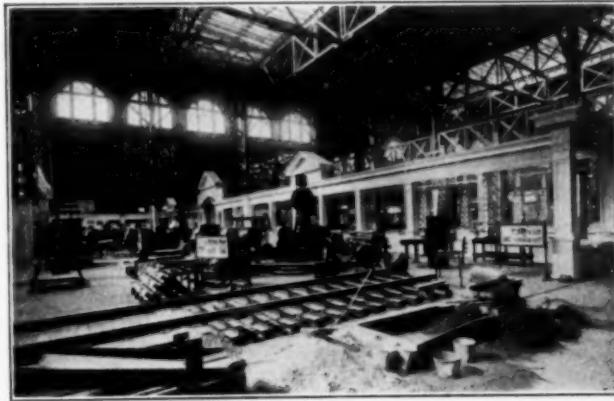
FIG. 2—U. S. STEEL CORPORATION EXHIBIT IN MINING PALACE IN COURSE OF ERECTION

out in the laboratory includes both hydro- and pyrometallurgy, and embraces a general study of the chemistry of ore roasting. An important part of the pyrometallurgical work consists in a microscopic study of the ores under investigation. Tentative plans have also been laid for investigations of methods for the extraction of gold and silver from complex ores and of processes for the recovery of sulphur from sulfide ores. Microscopic examination of slags from copper and lead ores to discover how the metal losses occur are contemplated as well as studies of methods for simultaneously abating the smelter fume nuisance and recovering the materials carried by the flue gases. In the assay work planned, which is under the direction of Prof. G. H. Clevenger, of Leland Stanford, Jr., University, an ef-

fort will be made to develop and standardize methods at the same time that the program of tests is being carried out. In fact, this idea of attempting to standardize processes will be carried out in each department of the Bureau where experiment is conducted during the exposition.

It is not the purposes of this article to chronicle a partial list of the exhibits in the Palace of Mines and Metallurgy, but it is interesting to note that there are here no less than three moving-picture theaters, the better to exemplify processes and methods that could not be brought indoors. One of these, depicting every stage of the mining of iron ore and the manufacture of steel products, has a sufficient length of film illustrating the subject to operate steadily for eight hours without repeating. New details of the processes for treating copper and lead ores are presented, as well as the equipment of latest design used in connection with the recently developed processes. Concentrators, cyanide plants, classifiers and jigs are shown in operation, as well as models of several types of furnaces and converters. As indicative of the diversity of exhibits it may also be noted that a magnificent pipe organ is installed in such a way as to display the metal tubes as a manufacturer's product, at the same time that a musician charms the visitors with selections from the old masters.

It will be a surprise to many metallurgists to see the exhibits placed in the Palace by China and Japan. The display of the latter country is unique in that it shows manufactured articles of various metals, especially sheet copper and copper wire, made in Japan to be shipped to America for competition here with homemade products. The quality and variety of the samples exhibited are of great interest to manufacturers, when it is remembered that these products were made where the labor cost is the equivalent of only a few cents per day.

To recapitulate, the Palace of Mines and Metallurgy is a university where day after day may be spent with its staff of instructors, many of them technical experts, who are at the service of the visitor, ready to demonstrate process or method which is the last word in each particular field. The scope of the field covered is limited only by the range of the industry itself, and never before have such successful efforts been put forth to portray each detail and make readily accessible for the visitor's observation every process of the industries represented. In short, Vice-President Marshall's comment after visiting the exposition applies particularly to the Palace of Mines and Metallurgy. In the course of dedicating the exposition on behalf of the United States, he said: "I came to bear a message. I remained to become a student. This is the university of the world. It has a chair fully endowed to meet the wants and needs of each. The eye, the ear, the mind, the heart, the soul, each may have its horizon here enlarged. If there be anyone in America with a thirst for knowledge and for beauty and a longing for a liberal education such an one can here obtain it. Whoever can, even at a sacrifice of something which for the moment appears necessary, should come to see a real work of art never equalled even by a mirage."

The Sarco Engineering Company, manufacturers of the Sarco steam traps, Sarco vacuum valves and Sarco temperature regulators, have moved their offices to the new South Ferry Building, 1 State street, New York City.

Dr. **Emil E. Lungwitz,** Eastern representative of the Kelly Filter Press, has moved his office to 30 Church street, New York City.

Personal

Mr. **Philip Argall,** manager of Stratton's Independence, has sailed for London.

Mr. **James Aston** has resigned his position as professor of metallurgy in the University of Cincinnati to accept a position in the Bureau of Mines, investigating efficiency and safety in the steel industry.

Mr. **D. D. Berolzheimer,** librarian of The Chemists' Club since 1910 and organizer and manager of the "Library Service" of The Chemists' Club in 1913, has resigned to become librarian of the Barrett Manufacturing Company, New York.

Dr. **Lucien I. Blake** will deliver the Commencement address at the Colorado School of Mines, May 28. For several weeks past he has been lecturing at the school on Molecular Physics.

Mr. **James F. B. Bowles,** formerly physiologist in charge of water supply and purification plants at Panama, and recently sanitary expert with the U. S. expeditionary forces at Vera Cruz, Mexico, has associated himself with the Lederle Laboratories of New York City.

Mr. **E. M. Breed,** who for the past eight years has been District Manager of the Canadian Allis-Chalmers Ltd., with headquarters at Vancouver, has been appointed District Manager of the Pelton Water Wheel Company. He will continue his headquarters at Vancouver.

Prof. **Joseph Daniels,** of the mining department of the University of Washington, Seattle, will be in charge of the State's mineral exhibit at the Panama-Pacific Exposition.

Mr. **Tenney C. DeSollar,** chief engineer for the Quincy Mining Co., Hancock, Mich., has been spending part of a vacation visiting in Colorado and Missouri.

Mr. **John H. Hall,** 2 Rector Street, New York City, has discontinued his practice as consulting engineer and enters on May 1 the employment of the Taylor-Wharton Iron and Steel Company, High Bridge, N. J., as metallurgical engineer.

Mr. **J. E. Johnson, Jr.,** consulting engineer of New York City, made an address on modern power plants in the iron and steel industry before the State College Engineering Association at State College, Pa., on March 9, 1915.

Prof. **James F. Kemp,** of Columbia University, delivered the address to the graduating class of the Michigan College of Mines.

Dr. **Arthur D. Little** having addressed the American Chemical Society at New Orleans on "The Industrial Resources and Opportunities of the South" on April 1 repeated this address on April 5 before the Atlanta Chamber of Commerce and the Georgia section of the American Chemical Society at the luncheon given by the chamber.

Mr. **K. C. Parrish,** who had been in Colombia for two years developing a mining and metallurgical enterprise, is to return to the United States for a holiday.

Mr. **J. F. Mitchell-Roberts** has resigned his position as chief engineer to the Wilfley Mining Machinery Company of London, to take up private work; he will be absent from London for about nine months.

Mr. **William Russell,** special representative of the Dorr Cyanide Machinery in London, has been visiting the principal metallurgical centers of the United States.

Mr. **Howard See**, of the research department of the American Rolling Mill Co., gave a lecture before the Colorado Section of the A. I. M. E., in Denver, April 9. His subject was "Methods and Processes of Pure Iron Manufacture." The lecture was illustrated by lantern slides showing the production from raw material to finished product.

Mr. **Thomas M. Skinner, Jr.**, metallurgist and assayer of Red Cliff, Col., has removed his office to Keeler, Cal.

Mr. **Robert C. Sticht**, general manager for the Mount Lyell Mining & Railway Co., has been elected president of the Australasian Institute of Mining Engineers.

Mr. **B. B. Thayer**, president of the Anaconda Copper Mining Co., is visiting the company's properties in Montana.

Mr. **E. E. Thum**, who has been superintendent of construction at Great Falls for the Anaconda Copper Mining Co., has resigned his position after eight years' service. He has been appointed professor of metallurgy in the University of Cincinnati.

Digest of U. S. Patents

Aqueous Bath, Electrodepositing, Aluminium
(*Complete prior to* 1903)

21,923, October 26, 1858, Luigi Ferrari Corbelli, of Florence, Grand Duchy of Tuscany, and Vincent Riatti, of the Duchy of Modena, assignors to L. F. Corbelli aforesaid.

Relates to the deposition of aluminium and manufacture of calomel. Several electrolytes are given, as follows: rock alum, 5931 parts, and chloride of calcium, 2076 parts; or the same quantity of rock alum with 2190 parts of chloride of sodium; or sulphate of aluminium, 4167 parts, and chloride of calcium, 2076 parts; or other aluminium salts may be substituted. The mixed, well-ground salts are dissolved in about two and one-half times their weight of water, filtered, and placed in a nonconducting vessel containing a layer of mercury on the bottom connected as anode by an insulated iron wire, the cathode being of zinc. A weak current is passed, chlorine being liberated at the anode forming protochloride of mercury, and aluminium separating at the cathode either as blackish powder or in a thin compact sheet.

140,924, July 15, 1873, John A. Jeançon, of Newport, Ky.

Relates to the deposition of aluminium, the electrolyte being any desired salt thereof, such as the sulphate, chloride, nitrate, acetate, cyanide, etc., or the double salt of aluminium and potassium, sodium, ammonium, or other metals, dissolved in distilled water and concentrated to 20 deg. Baumé (at 50 deg. Fahr.). The solution is heated to 140 deg. Fahr., a small quantity of free acid being present, which may be liberated by the addition of sulphuric acid. A plate of aluminium is used as the anode, the articles to be plated being first well cleaned and connected to the cathode. An electromotive force equal to four pairs of Smee's zinco-platinum plates, connected for intensity, is used. During the operation water and acid are added to replace that lost by evaporation, etc. If it is desirable to use solutions of aluminates as electrolytes, the solution must contain an excess of the alkaline hydrate, and the temperature at least 200 deg. Fahr.; the anode should be very small in proportion to the cathode, and is preferably of platinum. The battery power should be eight or ten large elements connected for quantity.

286,359, Oct. 9, 1883, William H. Williams, of Cincinnati, Ohio, assignor of one-third to Paul Mohr, of same place.

Relates to electrodepositing aluminium and prepares the electrolyte as follows: 2 lb. troy of dry clay or of oxide of aluminium, 2 lb. of sugar and 2 gal. of water are thoroughly mixed, allowed to settle, and filtered. To the clear portion is added 2 oz. of muriate of iron, sulphate of iron, or any other soluble salt of iron, and when the solution is effected, dissolve therein 32 oz. troy of tartaric acid. Then add slowly a strong solution of caustic potash, stirring constantly, until the tartaric acid appears to be exhausted. The mixture is then allowed to stand until the precipitate has settled, and filter. The solid portion remaining is a "salt" and may also be made by an alternative process, for which see the patent. Thirty-two ounces troy of the salt or of tartrate of aluminium are dissolved in 1 gal. of water with 28 oz. troy of cyanide of potassium and neutralized with 32 oz. of tartaric acid. A precipitate is formed which after settling is filtered, the liquid being condensed by evaporation to the point of crystallization, allowed to cool and crystallize and the crystals collected and dried upon a sieve. To prepare the plating bath 9 oz. of the crystallized salt are dissolved in 1 gal. of water for depositing upon copper; and 16 oz. of the crystals to 1 gal. of water for plating upon iron, with 1 oz. of cyanide of potassium for each 4 oz. of the crystallized salt. As anode either platinum or carbon may be used. The strength of the bath may be maintained by immersing therein a porous cup containing some undissolved crystallized salt or oxide of aluminium; or an anode of aluminium may be immersed in the porous cup without the crystallized salt. The cyanide solution obtained just before crystallization may be used as the electrolyte if desired.

436,895, Sept. 23, 1890, John A. Jeançon, of Newport, Ky.

Relates to the electrodeposition of aluminium from an anode consisting of mixed aluminium and preferably about 30 per cent of carbon, the thoroughly agitated molten mass being cast into thin plates. The electrolyte consists of a saturated solution of persulphate of aluminium, that is, an acid sulphate of aluminium requiring a high temperature, preferably about 180 deg. to 200 deg. Fahr., to prevent crystallization. The current is of very low intensity but of great quantity. The process is said to produce a dense and compact deposit of aluminium which may be burnished and buffed.

577,186, Feb. 16, 1897, Caleb Grozier Collins, of Woodsburg, N. Y., assignor to Calvin Amory Stevens, of New York, N. Y.

Relates to the electrodeposition of aluminium and describes a two-compartment cell, the anolyte consisting of a solution of aluminium sulphate made by dissolving alumina in sulphuric acid of 45 deg. Baumé using a carbon anode or a dilute sulphuric acid with an anode of aluminium. The catholyte consists of a 20-deg. Baumé solution of potash to which is added tartaric acid or any other derivative of pure argol in the proportion of about two-tenths by weight of the potash used, there is then added about 2 lb. of phosphate of aluminium per gallon of the solution; when the phosphate is dissolved then add aqua ammonia of 26-deg. strength in the proportion of 3 per cent of the whole solution. Within the catholyte is placed the article to be electroplated.

A 2600-lb. silver nugget was discovered March 23 on the Townsite property, Cobalt, Canada. The slab was approximately four feet square and ten inches thick. This nugget is much heavier than the famous Cobalt Gem nugget, but not so rich. It was uncovered a few feet below the surface while making an open cut on a vein on the Townsite property.

Book Reviews

Concentrating Ores by Flotation. By **Theodore T. Hoover.** 221 pages, 55 illustrations; price $3.75. London: The Mining Magazine. San Francisco: Mining Press.

To quote the preface, "this is a report of progress in a rapidly developing art". The author was for four years general manager of the Mineral Separation, Ltd., but states that the said company is not necessarily in agreement with all the opinions expressed in the book, "and, in fact, quite properly opposes some of the views set forth." Learning that his friends Sulman and Picard, with whom he had been professionally associated, are preparing a book on "Theories of Concentration Processes Involving Surface Tension," the author has refrained from giving any new and unpublished information of this nature. Aside from this, the reader will find the flotation methods thoroughly considered particularly in their historical, chronological and legal aspects and relations. It is a timely and high-grade book.

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Mining Costs of the World. By **Edmond Norton Skinner** and **H. Robinson Plate.** 406 pages with maps and tables. New York: McGraw-Hill Book Company, Inc. Price (flexible morocco) $5.00.

These two mining engineers have laboriously compiled, for the benefit of engineers, managers, operators and students, from companies' annual reports, financial statements and direct communications, costs and other important operating data on 325 metal mines in different parts of the world. The book is therefore, in one way, not as broad as its title indicates. On the other hand, however, it is broader than its title, since it gives something more than costs; there are added in most cases brief descriptions of the mines, the methods of mining and reduction employed, and general information as to operating conditions. The whole makes a valuable reference book for economic geologists, mining engineers and metallurgists. The maps are poor, but the rest of the book is a credit to the publishers.

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Iron Ores. By **Edwin C. Eckel.** 430 pages, 64 maps and diagrams. Price $4.00. New York: McGraw-Hill Book Company.

The book consists of three sections: I, the origin of iron-ore deposits; II, the valuation of iron-ore properties; III, the iron-ores of the world. Each section is handled in a masterly manner. Valuable chapters in Part II are those on prospecting and tonnage determinations, mining conditions and costs, and ore prices, profits and markets. In the last section the author shows a wonderful acquaintance with iron deposits almost all over the world; he criticises and revises many of the careless estimates made in the "Iron Ore Reserves of the World", printed by the International Geological Congress in 1910, and in particular he discusses most competently what should be called "ore reserves," actual and possible, and the effect of improved metallurgical methods in extending the limits of workable and treatable ore. No such masterful presentation of the subject has been published in any language, and we heartily congratulate the author on the great value of his work.

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Assaying, in Theory and Practice. By **E. A. Wright.** 324 pages, 70 illlus. Price $3.00 *net.* London: Edward Arnold. New York: Longmans, Greene & Co.

"Assaying," says a technological dictionary of date 1846, is "the determining of the amount of gold or silver in an ore." Expanding with developing industries, it became "the determination of the amount of a useful metal in an ore." The subject has now become " dry assaying" and "wet assaying." The former connoting furnace methods, the latter such ordinary analytical methods as are suited to the purposé. The latter differs from analysis only in its singleness of purpose, namely, to single out, separate and determine the amount of the one useful metal.

Mr. Wraight taught assaying, in the broader sense of the term, for twelve years in the Royal School of Mines, London. The book is redolent of the ancient assay laboratory, and at its best when describing the older fire methods, although even here it is inferior to one or more American books which could be mentioned. In the field of "wet assays," where it is to be judged by the methods of advanced analytical chemistry, it is in many places antiquated. It is, moreover, fragmentary to an exasperating degree: no mention whatever is made of determination of, or even testing for, platinum or the platinum metals, in either the dry or wet way; recipes are put forth at times without attempting to explain their why or wherefore.

The practical part of the book is good, as far as it goes, but the work as a whole will be disappointing to those wanting a modern, complete and up-to-date book on assaying.

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The Raw Materials for the Enamel Industry and Their Chemical Technology. By **Julius Grunwald.** Translated from the German, by **Herbert H. Hodgson** 226 pages, 21 illus. Price $2.75. London: Charles Griffin & Company, Ltd. Philadelphia; J. B. Lippincott Company.

This is the third work of Dr. Grünwald's which Dr. Hodgson has translated; the preceding ones were "Enamelling on Iron and Steel" and "Iron Enamelling and Tinning." The present book lays the foundation for these industries by discussing in great detail the character of the materials used in making enamels, their occurrence in nature and their preparation for the application by the enameller. There is little technical literature on this subject, although great advances have been made by the entrance of scientifically trained men into the business. The book treats of the chemical and mineralogical technology of feldspar, quartz, fluorspar, clay, borax, cryolite, pyrolusite, tin oxide, nickel oxide, cobalt oxide, soda, saltpeter, potash, enamelling pigments, and some other miscellaneous materials—all from the standpoint of their use in the enamel industry, but particularly as it has been developed in Germany and Austria-Hungary.

The work, besides being valuable to those making enamels cannot but be useful in progressive men in the ceramic industries, and will also interest students of the chemistry of easily fusible salts and salt mixtures, particularly the low fusing point silicates and slags.

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Geschichte des Elektroeisens.—Von Dr. Tech. OSWALD MEYER. 15 x 23 cm., 187 pages, 206 illustrations. Price, 8 marks ($2). Berlin: Julius Springer.

A careful compilation of the history of the electric furnace manufacture of iron, complete and well illustrated. It can hardly be called critical, since good, bad and indifferent furnaces and processes are described in somewhat similar and optimistic language. If read critically, however, no harm is done. A very complete table of 238 electric steel furnaces in operation or construction gives a vivid tableaux of the great development of the electric steel industry.